



quarterly **a**nalysis review

17.2
2Q 2017

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24 july 2017

topics

1

energy markets

automotive markets

technologies studies

environmental studies

consumers & opinion surveys

policy & business studies

qar

outline

1 energy markets

vehicle fuels

- > EIA: Gasoline prices remain near lowest levels in a decade
- > EIA: Price difference between premium and regular gasoline is growing
- > EAFO: LPG and CNG fuels are somewhat popular in Europe

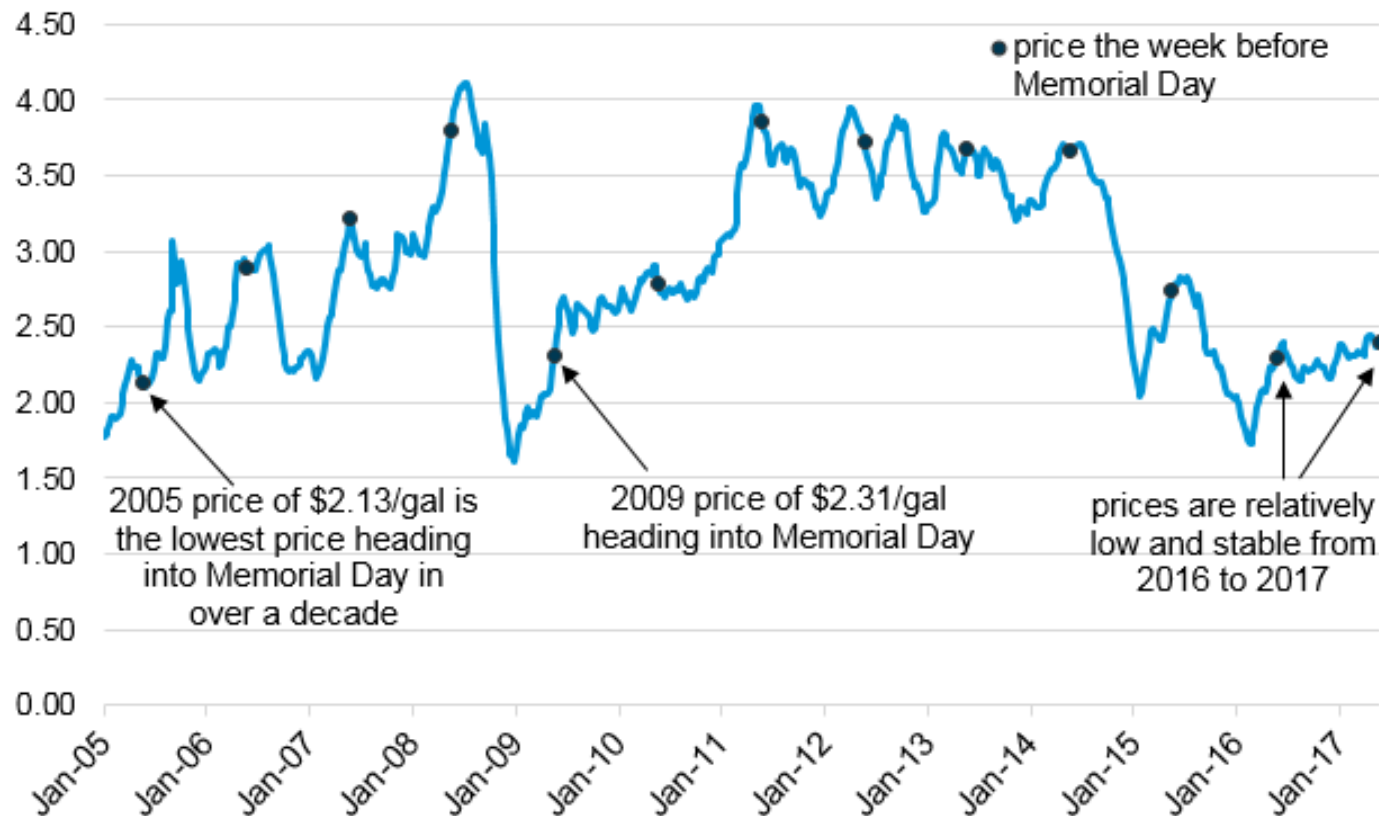
energy markets/production

- > EIA: U.S. gasoline consumption grew in 2016, still below peak
- > EIA: Crude oil exports are growing since regulations lifted
- > IEA: Conventional crude resources are growing slower than any time since 2000

gasoline prices

EIA: Gasoline prices have been relatively low and stable from 2016 to 2017

Figure 1. U.S. average regular gasoline price
dollars per gallon

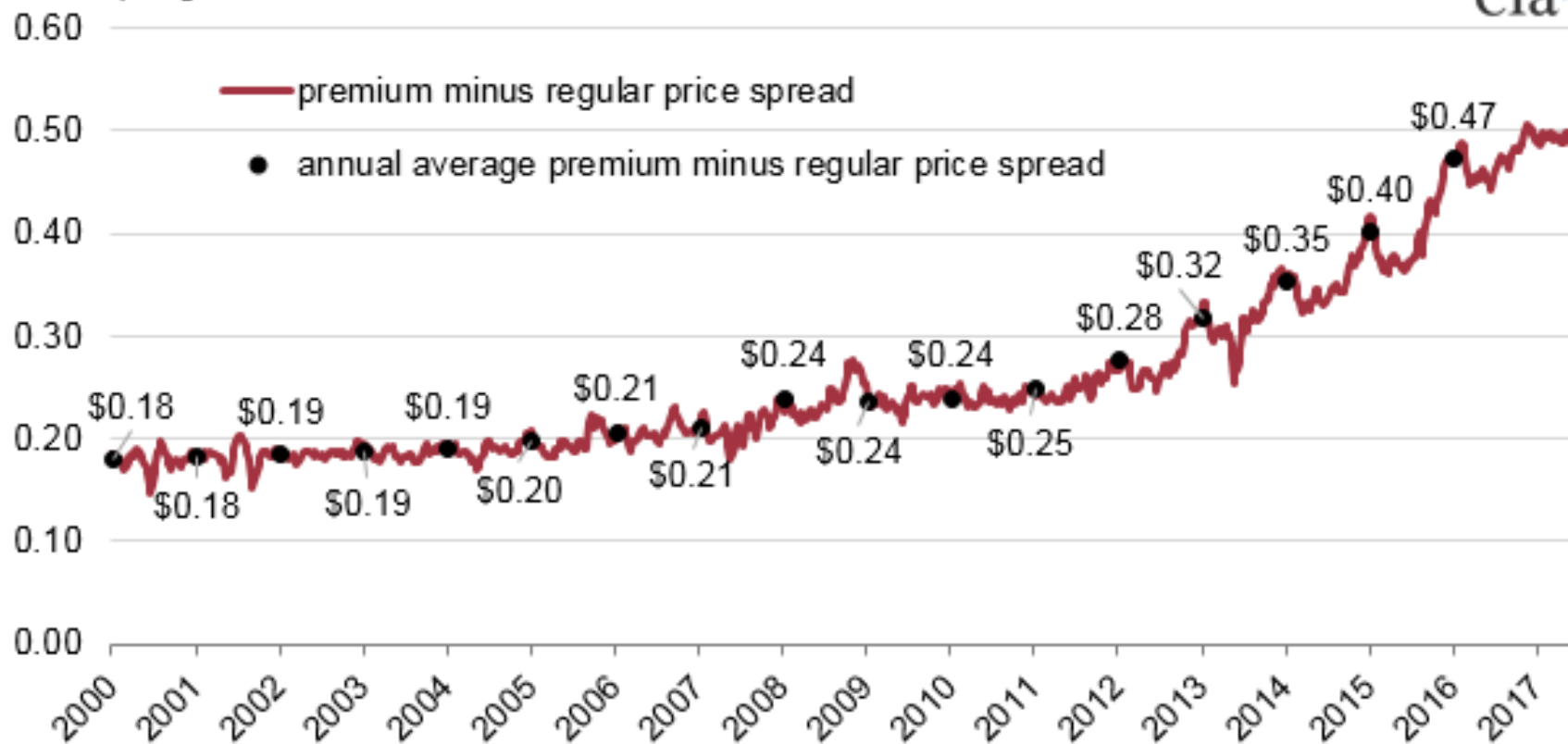


Source: U.S. Energy Information Administration

gasoline prices

EIA: Difference between premium and regular gasoline prices has doubled since 2011

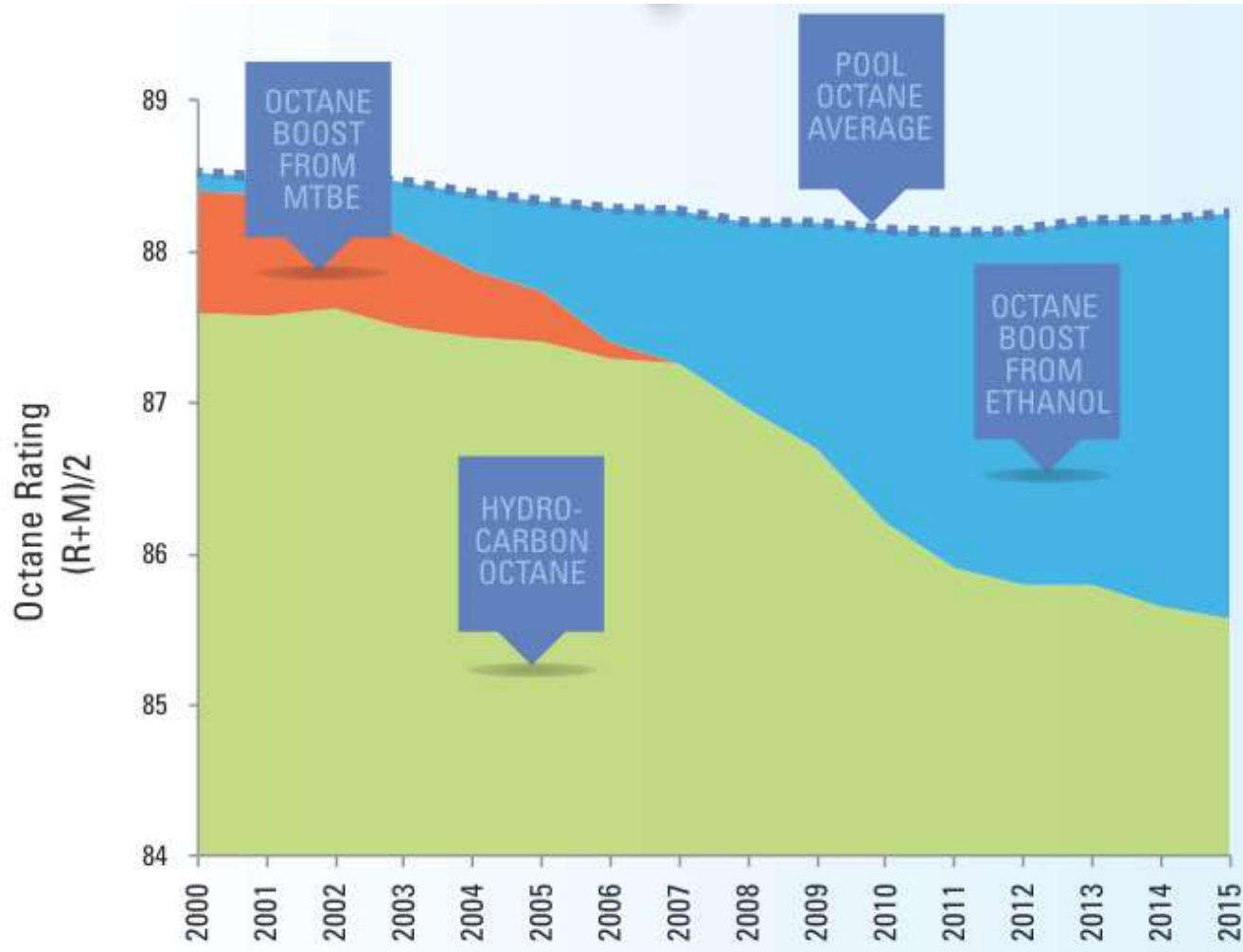
Figure 1. Retail gasoline price differential
dollars per gallon



Source: U.S. Energy Information Administration, Gasoline and Diesel Fuel Update.

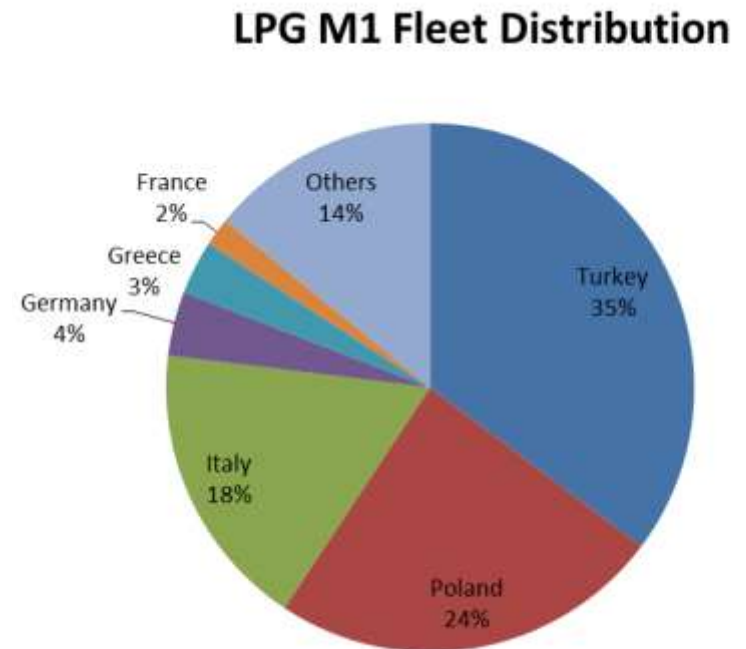
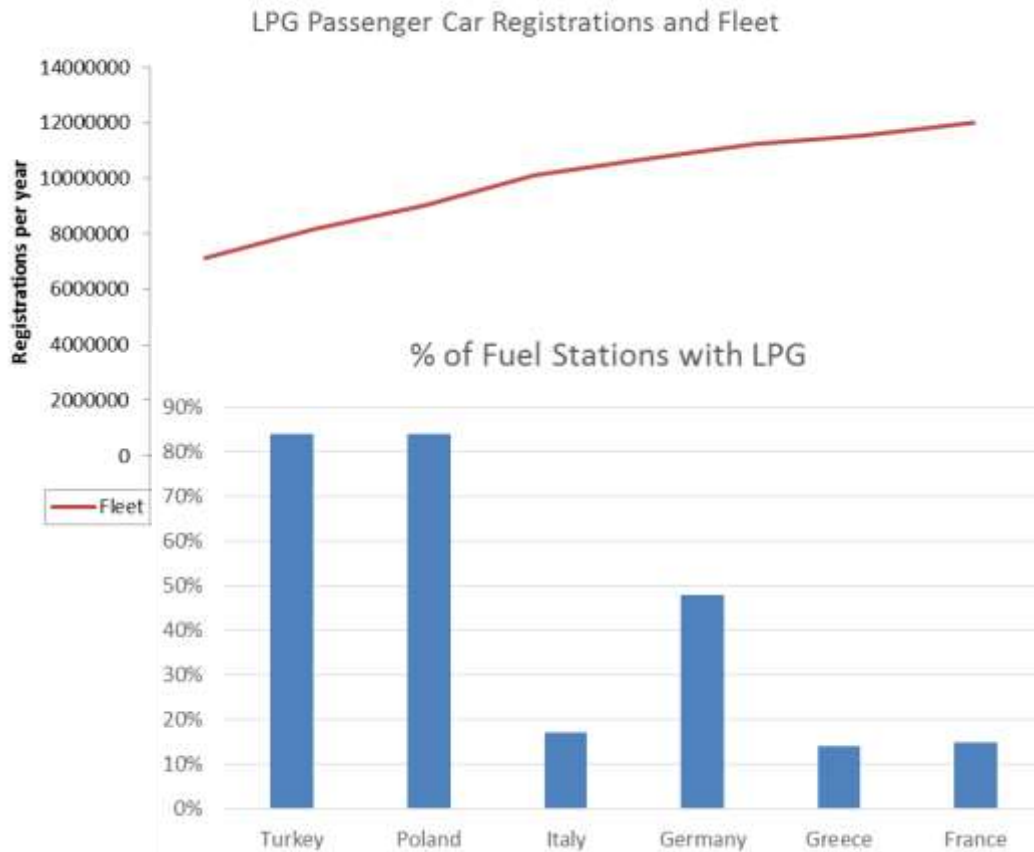
biofuels

RFA: Octane from hydrocarbon sources are dropping, while ethanol gives octane boost



LPG usage

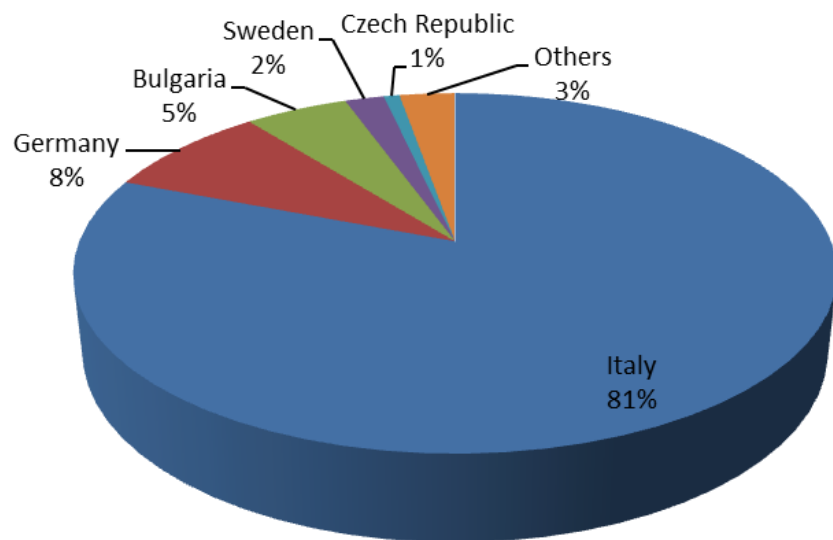
EAFO: 12 million LPG vehicles on roads in Europe; LPG fuel readily available in Turkey and Poland



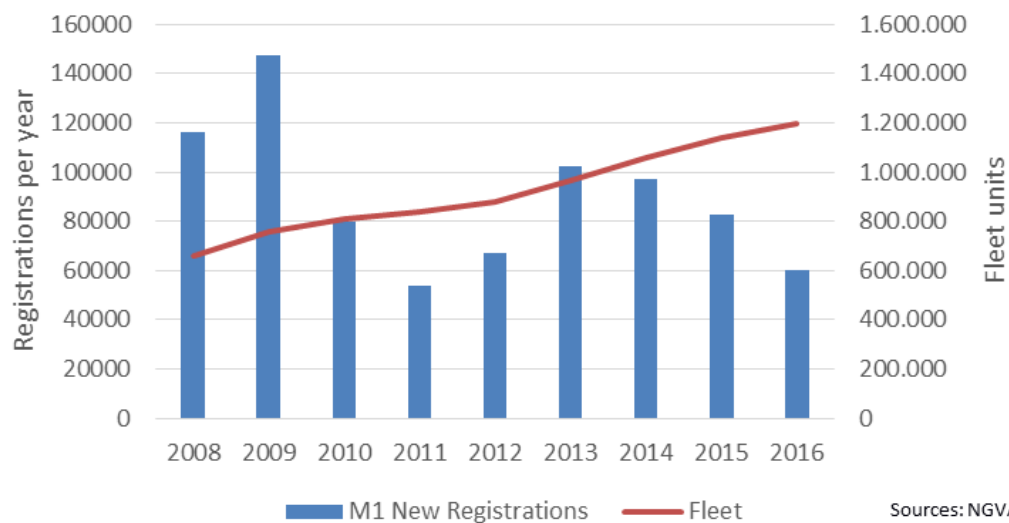
CNG usage

EAFO: Over 1.2 million CNG on roads in Europe; Italy responsible for lion's share of CNG vehicles

NG M1 Fleet Distribution



NG Passenger Car evolution

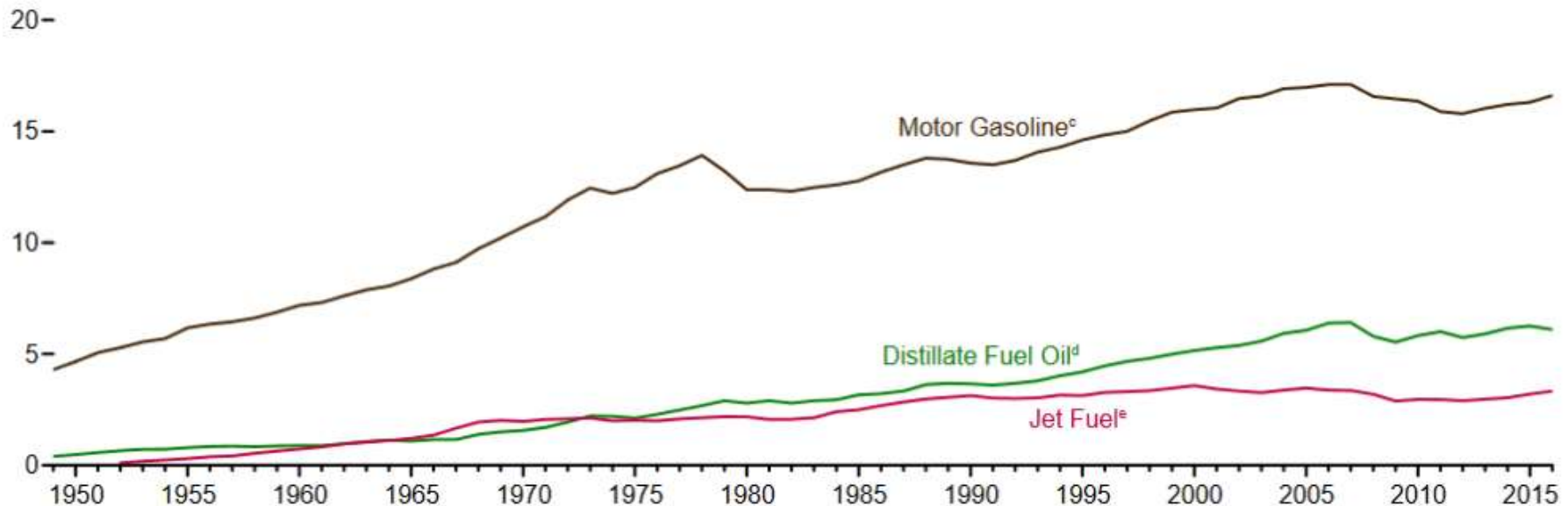


Sources: NGVA, ACEA and EAFO

oil markets

EIA: U.S. motor gasoline usage near all-time high in 2016, lower than peak in 2007

Transportation Sector, Selected Products



^a Includes combined-heat-and-power plants and a small number of electricity-only plants.

^b Liquefied petroleum gases.

^c Beginning in 1993, includes fuel ethanol blended into motor gasoline.

^d Beginning in 2009, includes renewable diesel fuel (including biodiesel) blended into distillate fuel oil.

^e Beginning in 2005, includes kerosene-type jet fuel only.

Note: Petroleum products supplied is an approximation of petroleum consumption and is synonymous with the term "petroleum consumption" in Tables 3.7a–3.8c. Other measurements of consumption by fuel type or sector may differ. For example, jet fuel product supplied may not equal jet fuel consumed by U.S.-flagged aircraft.

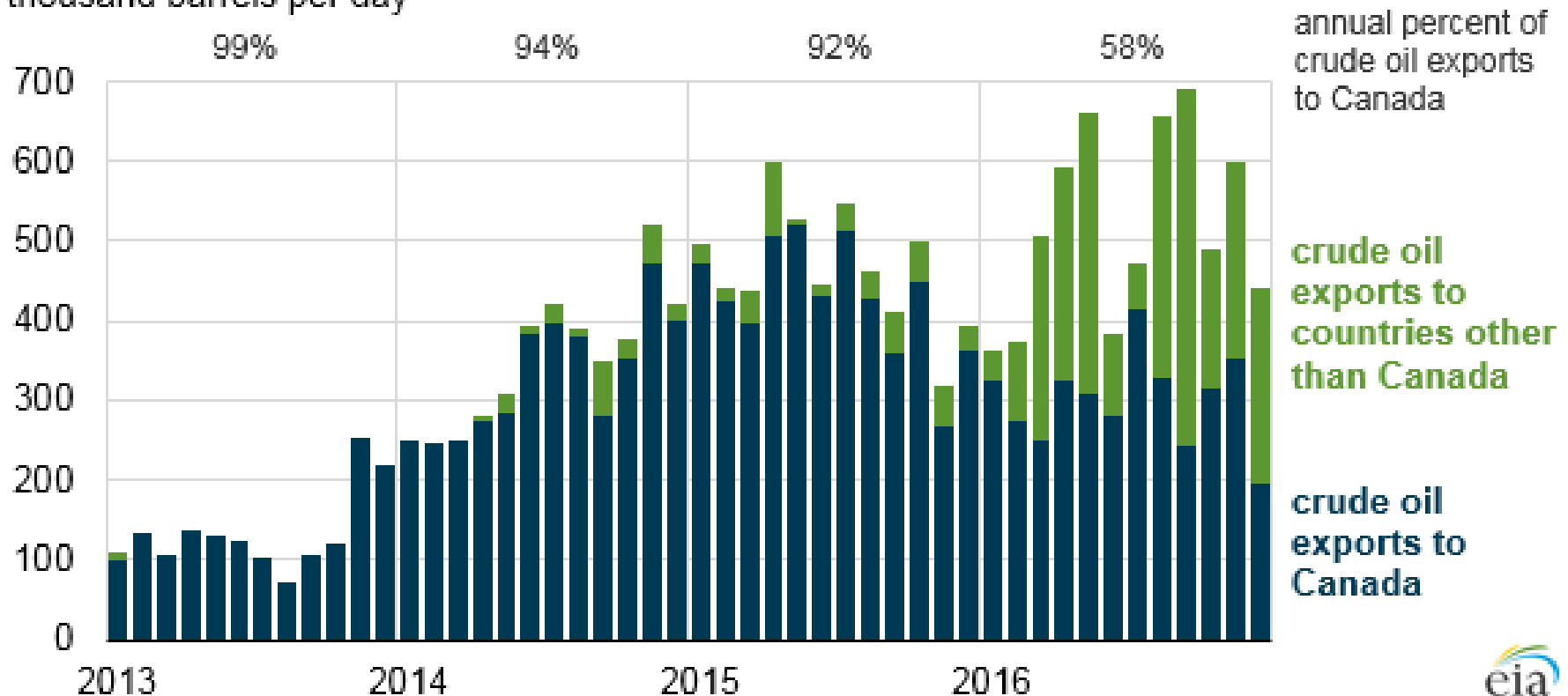
Web Page: <http://www.eia.gov/totalenergy/data/monthly/#petroleum>.

Sources: Tables 3.8a–3.8c.

oil markets

EIA: Removal of restrictions has opened U.S. crude exports to countries worldwide

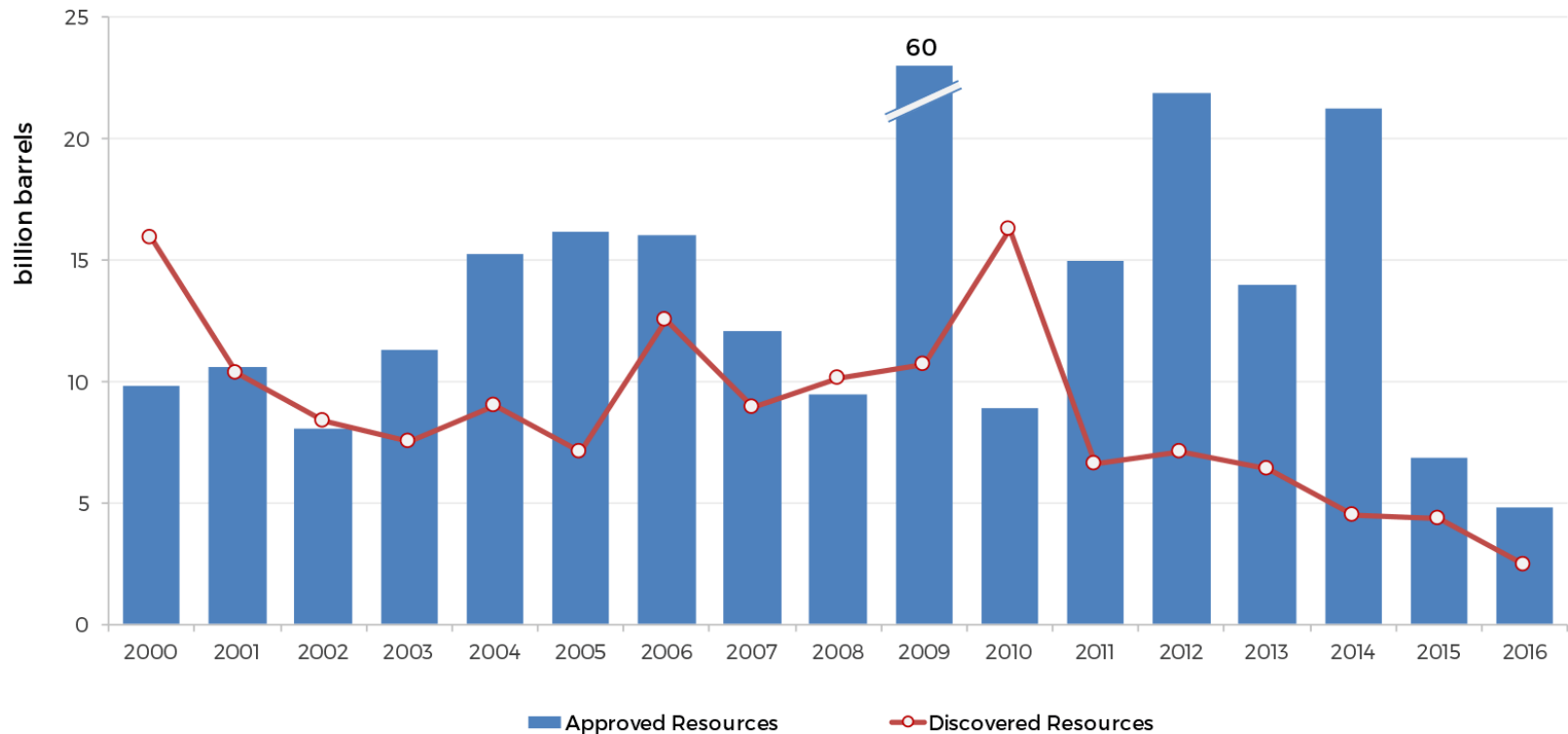
Monthly U.S. crude oil exports (Jan 2013 - Dec 2016)
thousand barrels per day



oil markets

IEA: Conventional crude discoveries and development at lowest levels in 15+ years

Conventional crude oil resources discovered & sanctioned by year



topics

energy markets

2 automotive markets

technologies studies

environmental studies

consumers & opinion surveys

policy & business studies

qar
outline

2 automotive markets

LDV market

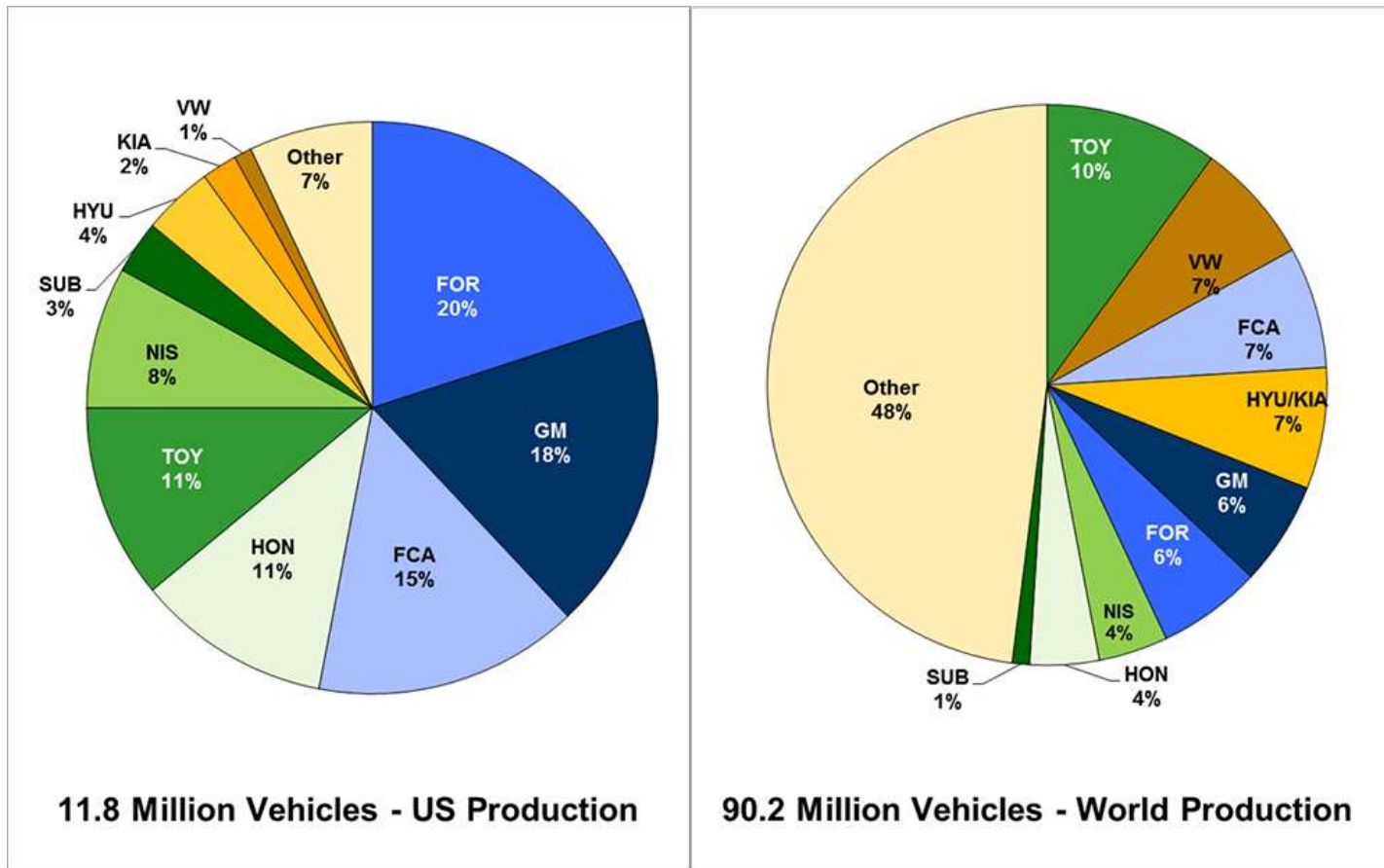
- > FOTW: 13% of vehicles worldwide are produced in U.S.
- > FOTW: Half of U.S. production comes from Ford, GM, and FCA

PEV market

- > FOTW: U.S. PEV sales grew 40% in 2016
- > FOTW: China is the largest market for PEV (by number)
- > FOTW: Norway is the largest market for PEV (by percentage)

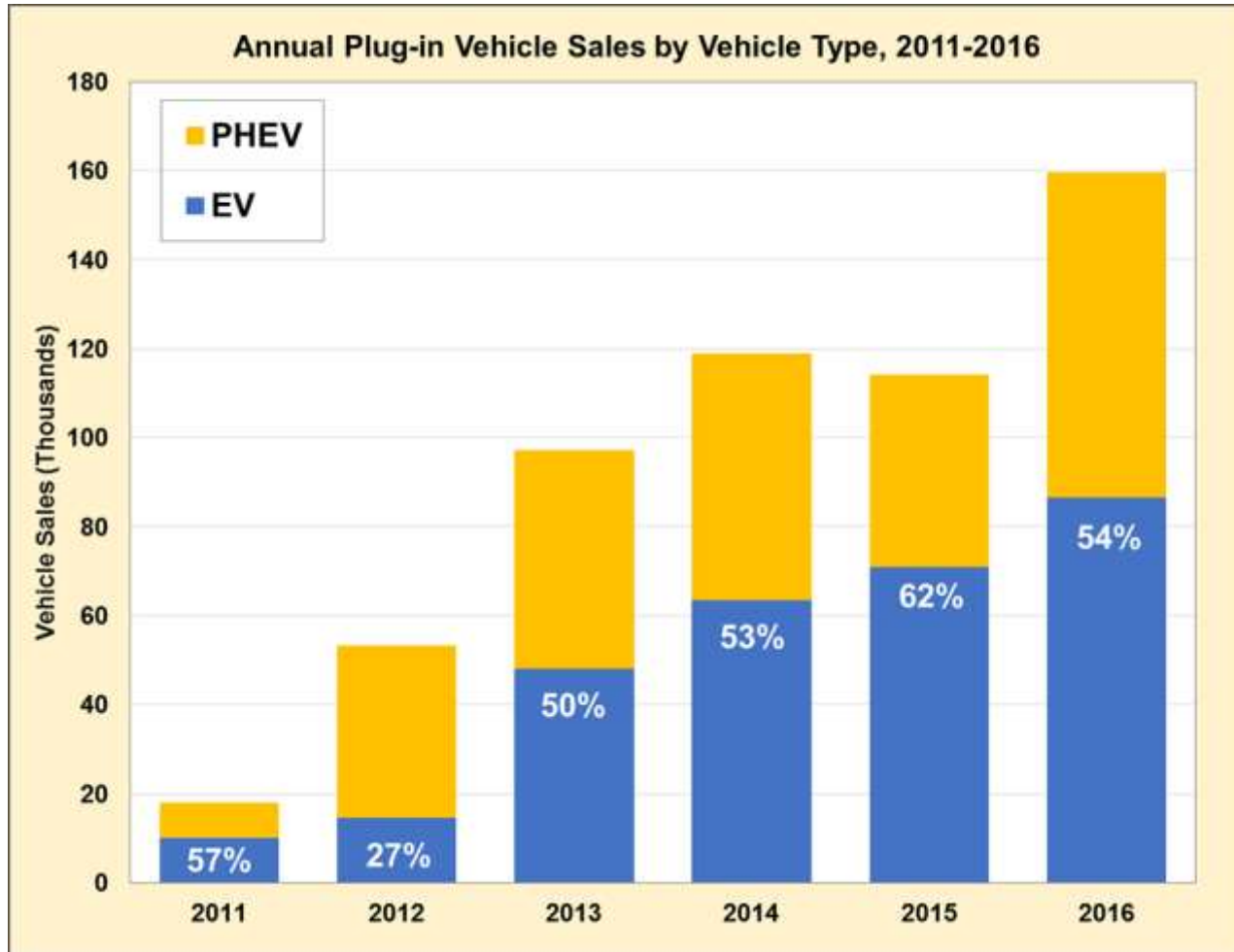
LDV market

FOTW: Thirteen percent of vehicles worldwide are produced in the United States; half of U.S. production comes from Ford, GM, and FCA



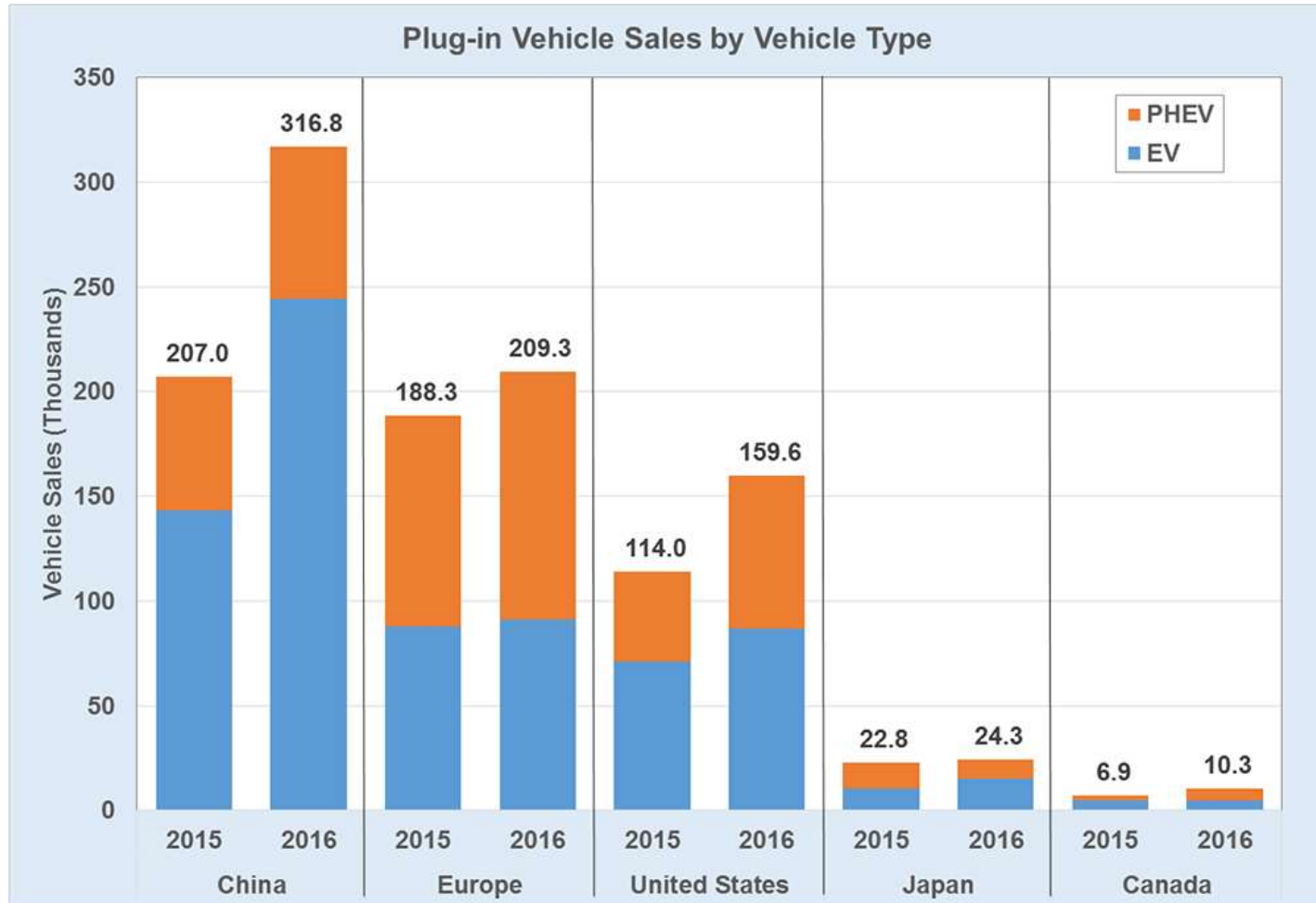
PEV market

FOTW: PEV sales increased 40% in 2016; BEVs are over half of PEV market



PEV market

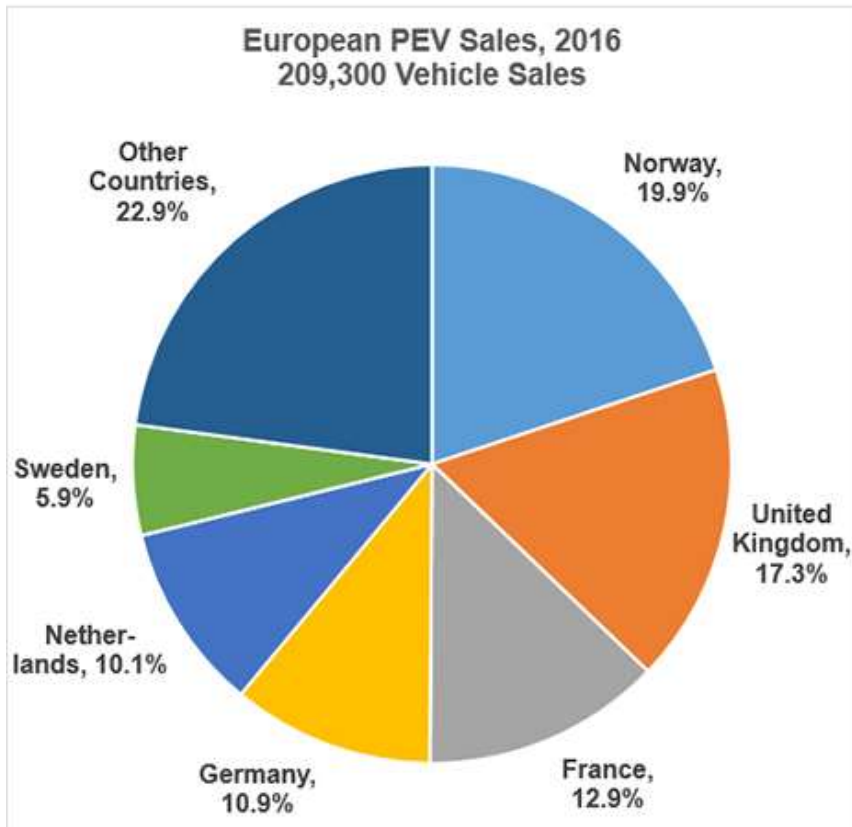
FOTW: China has the highest number of sales of PEV in the world



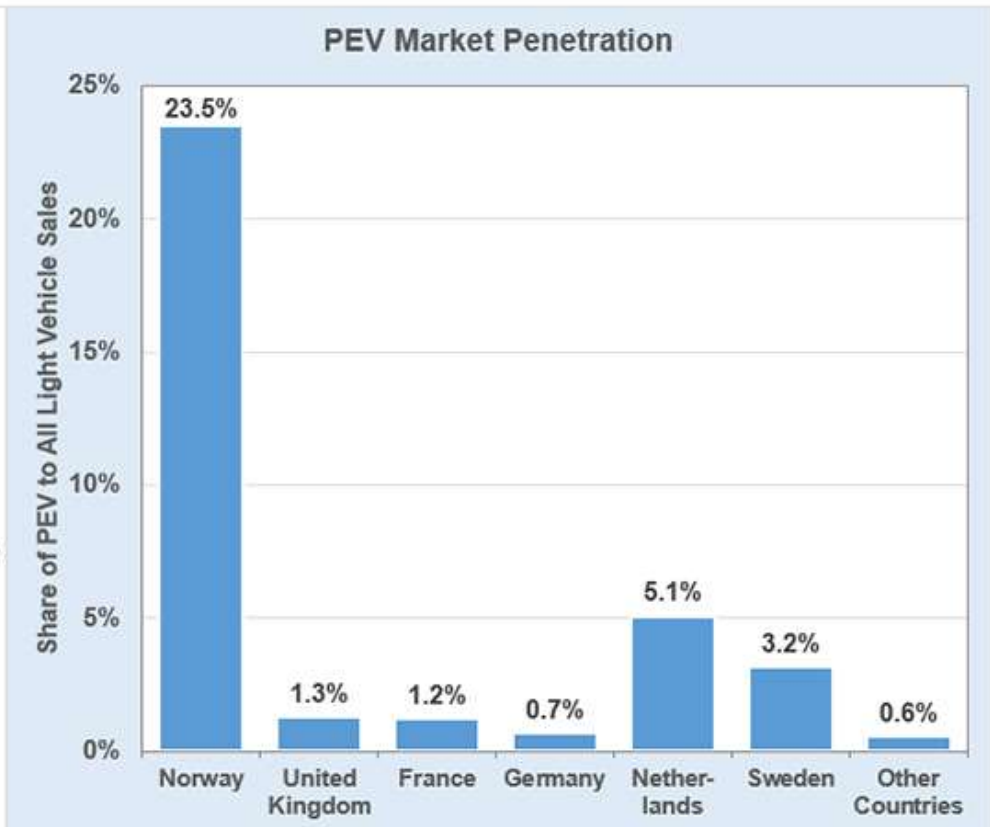
PEV market

FOTW: Nearly one-fourth of vehicles sold in Norway in 2016 were plug-in vehicles

Plug-in Vehicle Sales by Country, 2016



PEV Market Penetration by Country, 2016



topics

energy markets

automotive markets

3 technologies studies

environmental studies

consumers & opinion surveys

policy & business studies

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outline

3 technologies studies

vehicle technologies

- > FOTW: Fuel economy has improved as new technologies have been introduced to vehicles
- > VTO: Lightweighting benefits can be amplified by drivetrain downsizing
- > UBS: Chevy Bolt less expensive to produce than expected; EVs can be profitable for OEMs within a few years

electric grid management

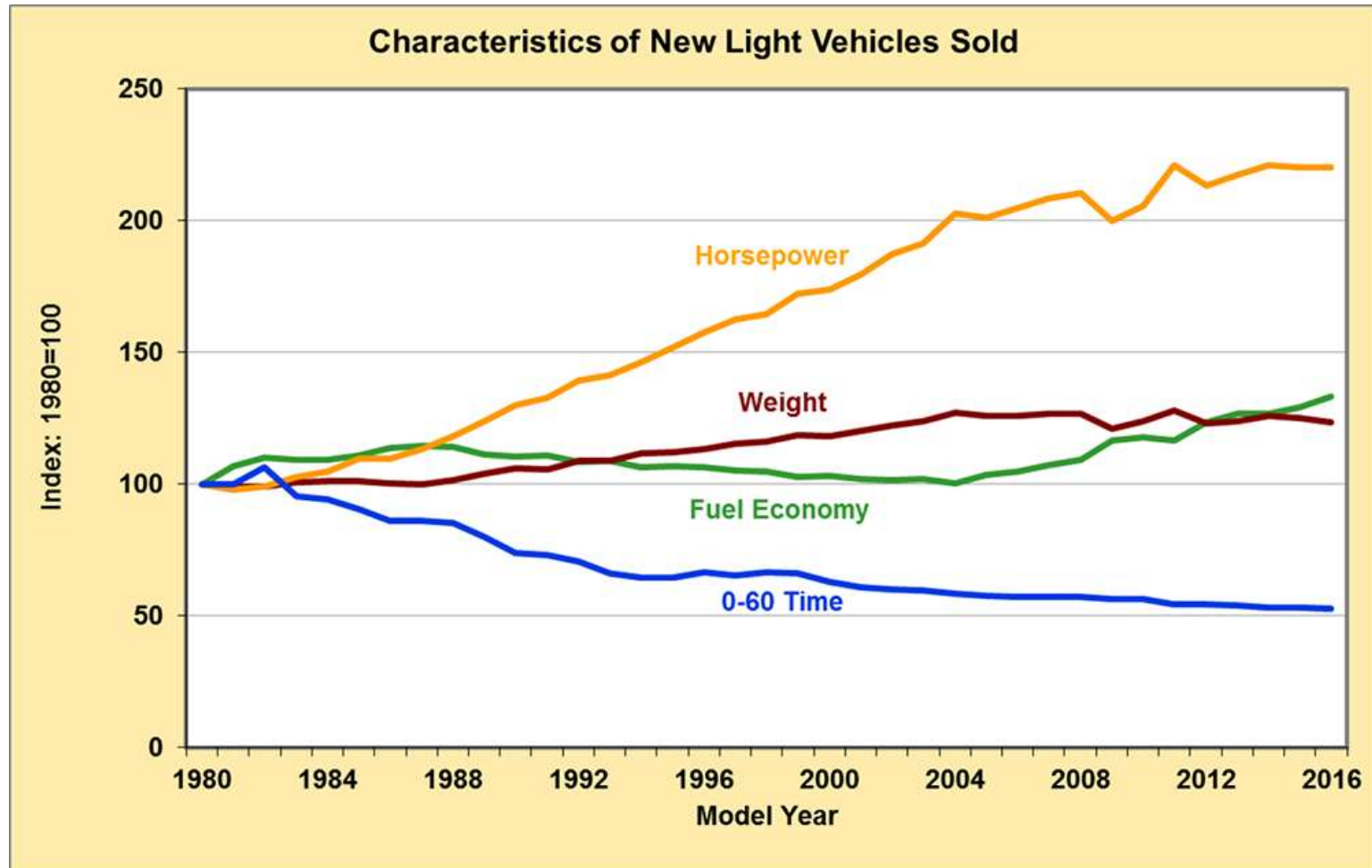
- > SEPA: Utilities are interested in managing PEV charging
- > Warwick: Using PEVs for grid demand response can potentially increase battery lifetime

CAVs

- > EIA: Connectivity and automation have potentially to change energy use
- > UIUC: A single AV can dampen traffic waves and improve fuel economy for multiple vehicles

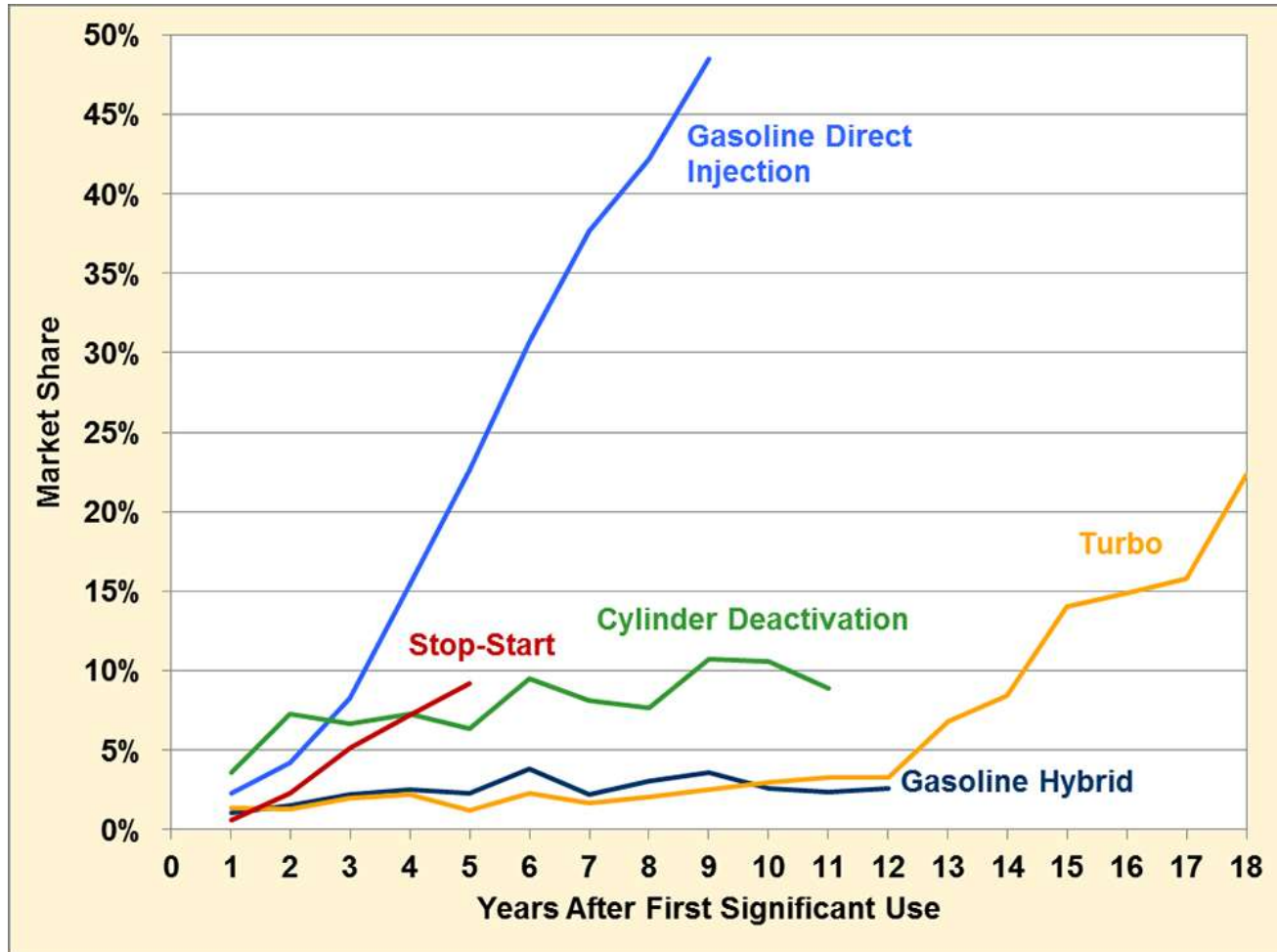
vehicle technologies

FOTW: Fuel economy has improved over 3 decades in spite of heavier vehicles and improved performance



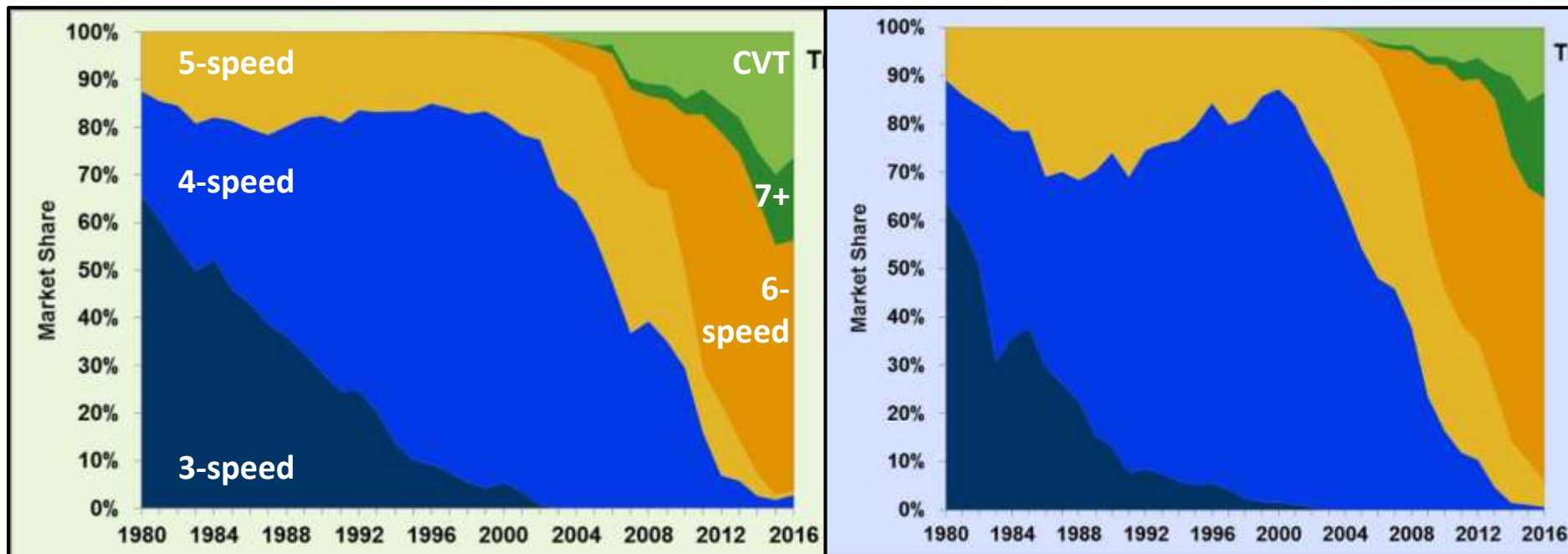
vehicle technologies

FOTW: Gasoline direct injection reaches half of LDV market within 9 years after first significant use



transmissions

FOTW: More than one-third of new transmissions in 2016 had a high number of gears



Transmission Speeds for Cars

Transmission Speeds for Light Trucks

transmissions

ICCT: Automatic and automated manual transmissions have grown in popularity in heavy-duty trucks

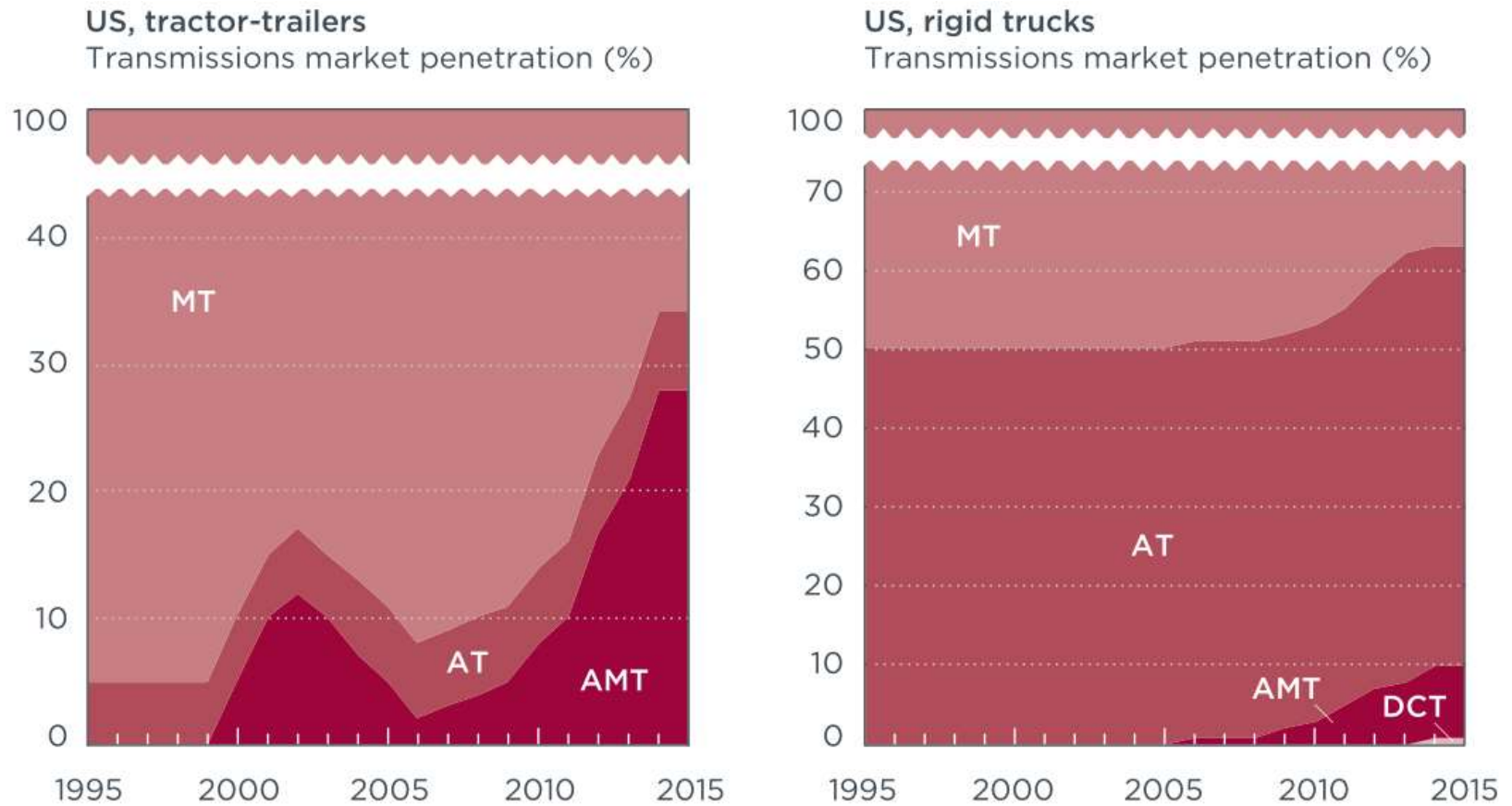
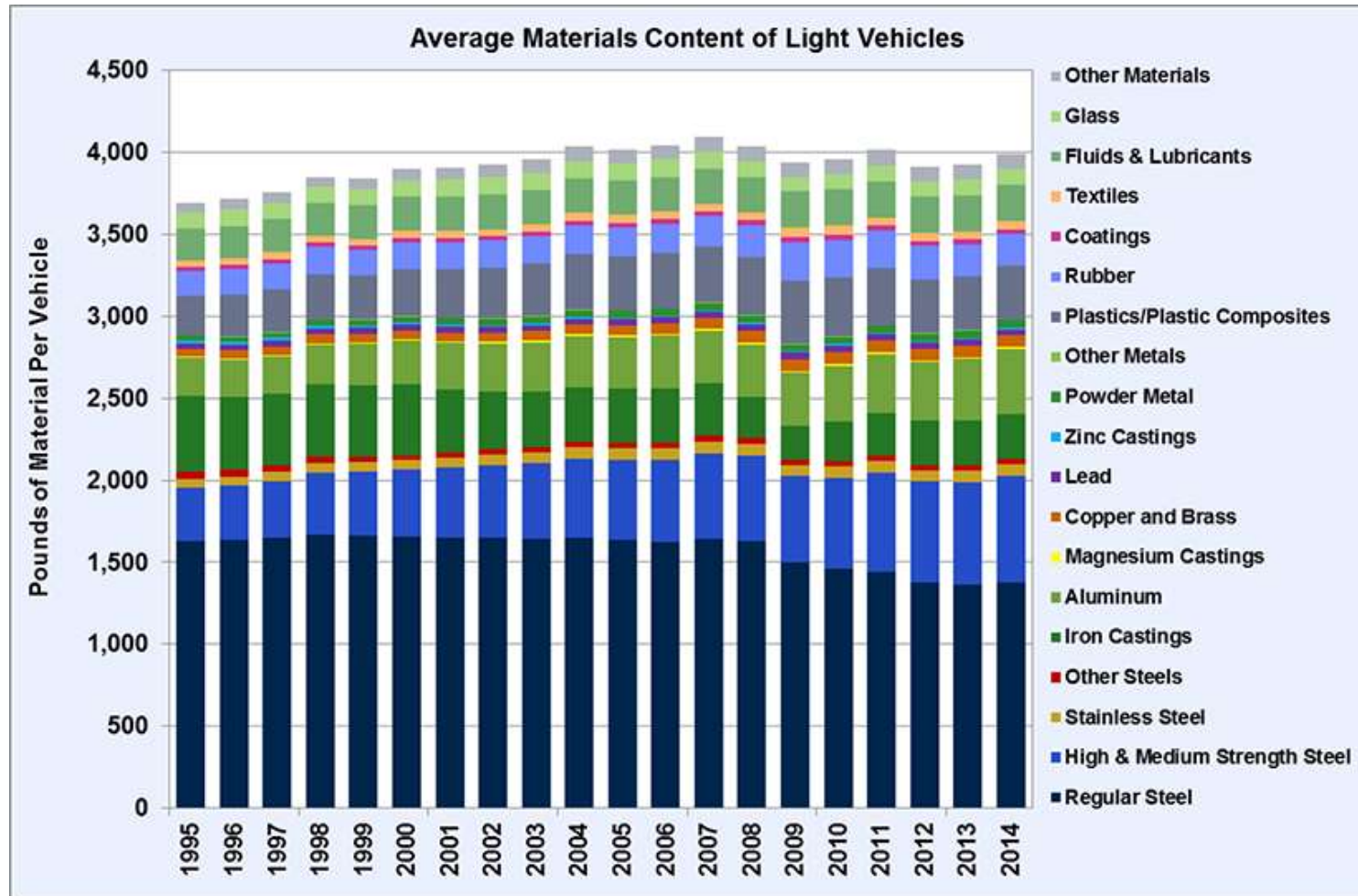


Figure 6. Market penetration of different transmission types in the U.S. (high confidence).

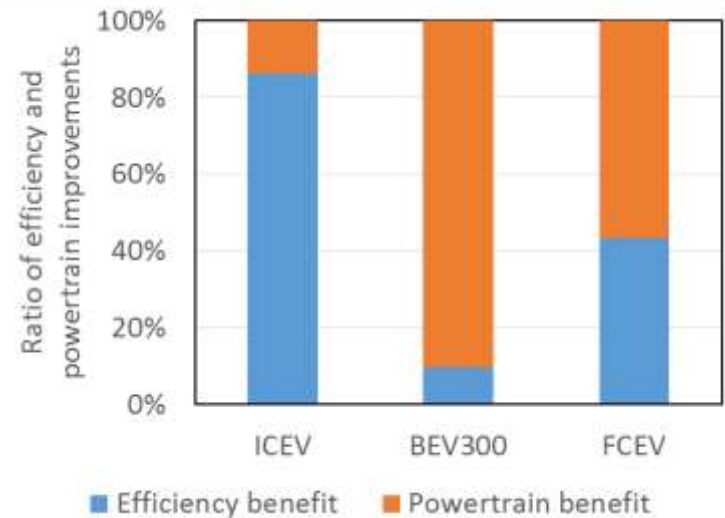
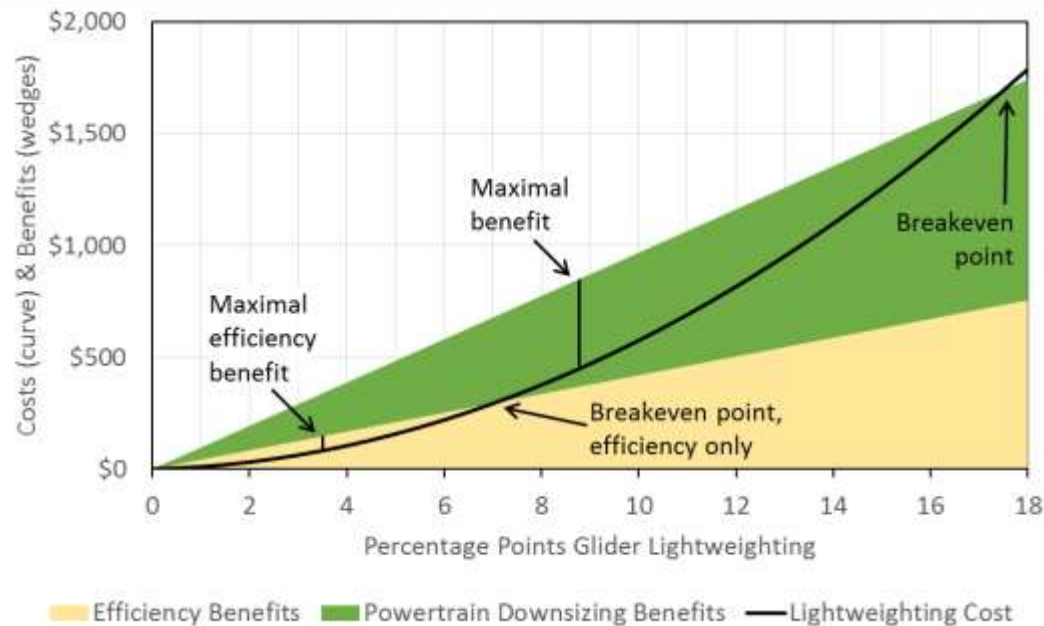
materials

FOTW: Use of lightweight materials has increased in the last 20 years



materials

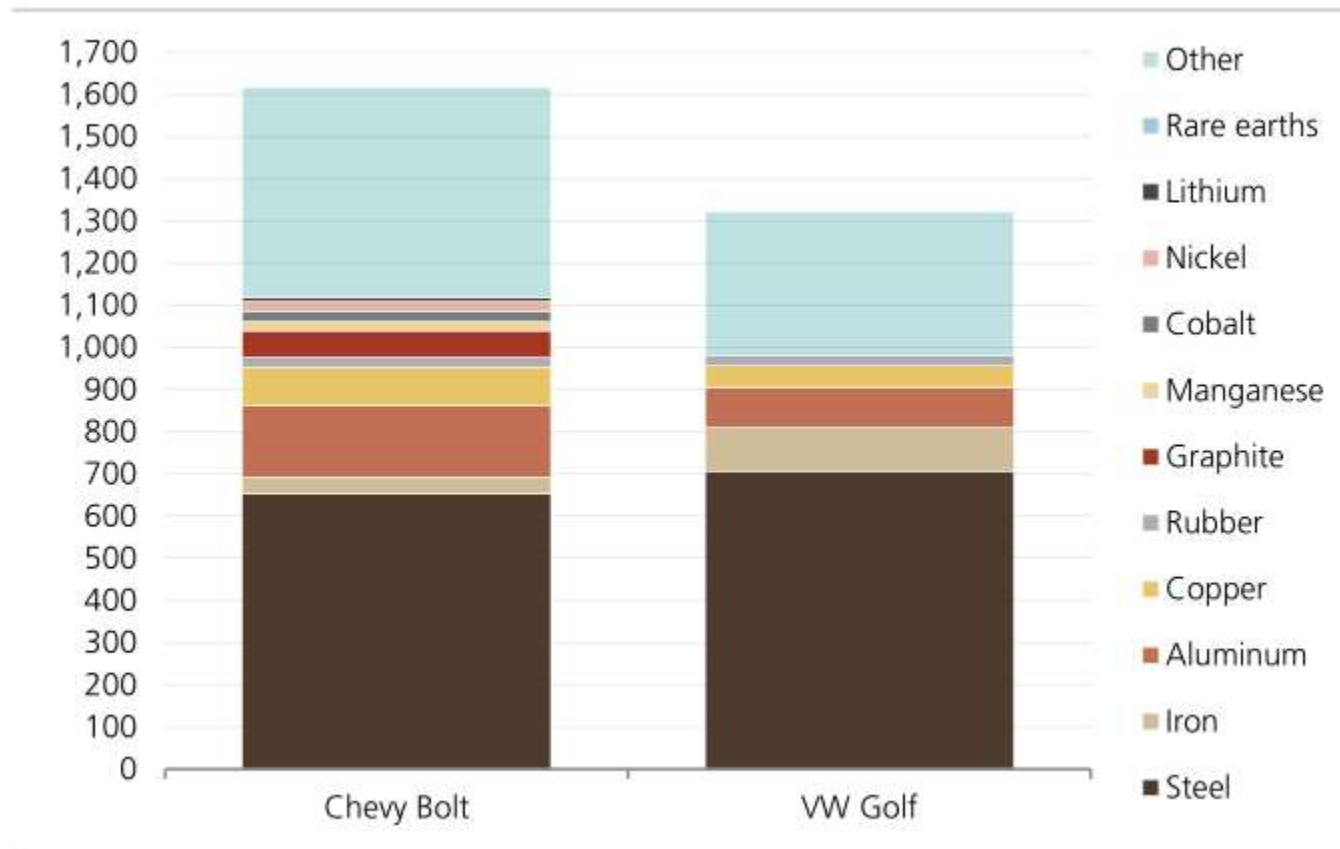
VTO: Lightweight materials potentially enable cost reduction through drivetrain downsizing



materials

UBS: Chevy Bolt teardown shows reduced steel and iron usage, more aluminum, copper, and graphite

Figure 44: Chevy Bolt vs. VW Golf commodity mix (kg)

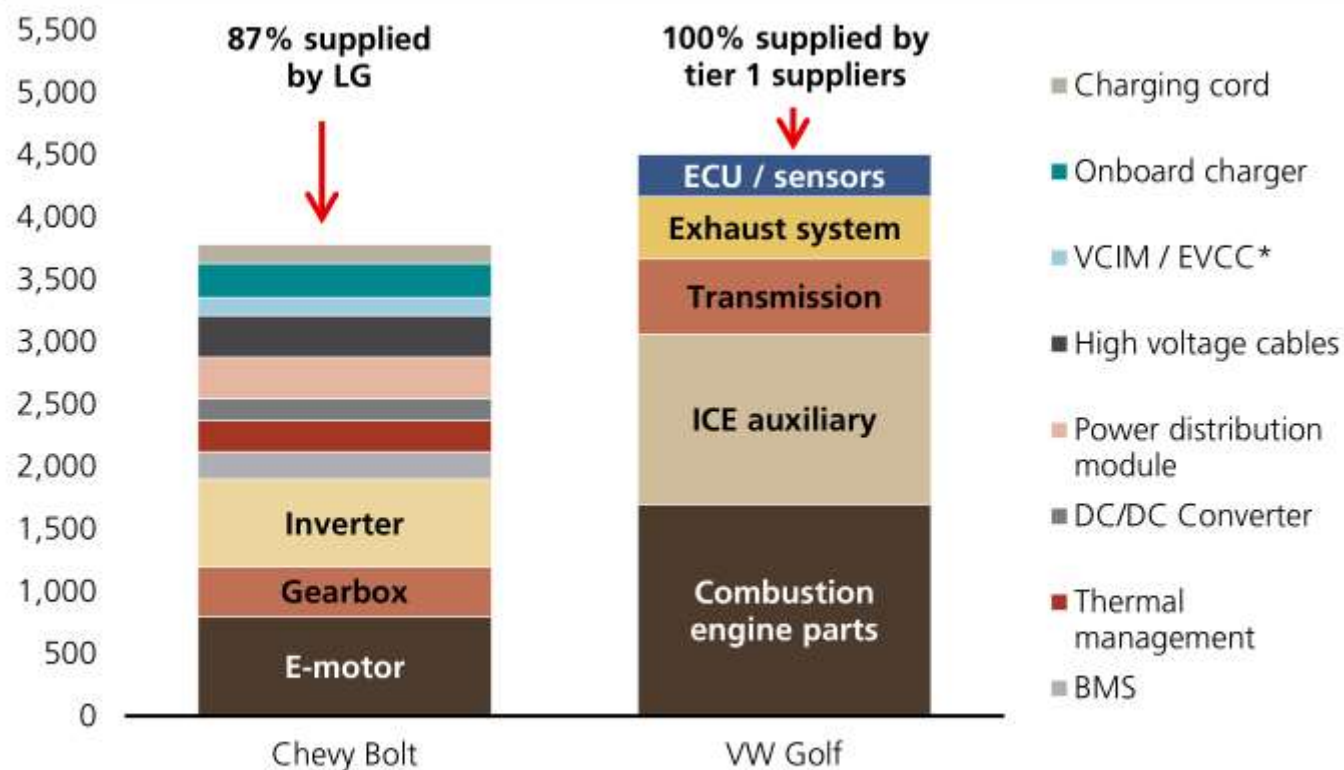


Source: UBS estimates

battery technologies

UBS: EV powertrain 16% cheaper than similarly performing ICE powertrain

Figure 48: Powertrain components – Bolt vs. Golf (\$)



Source: UBS estimates

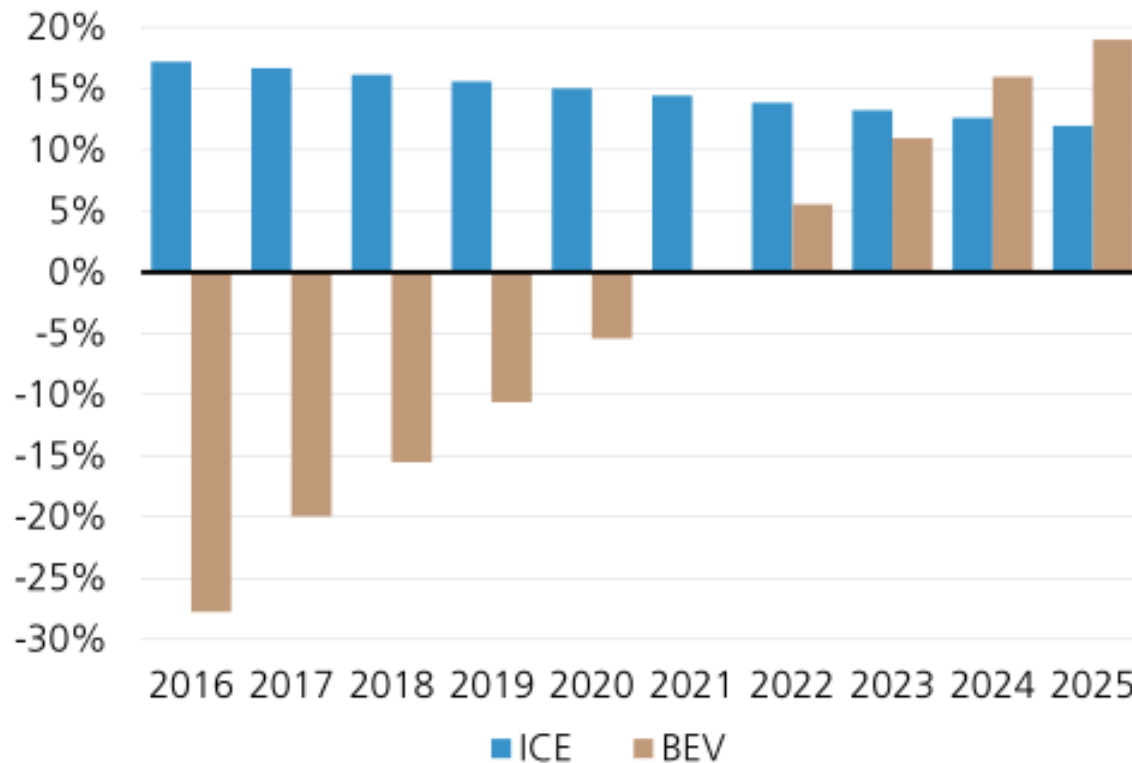
* VCIM = Vehicle interface control module

** EVCC = Electric vehicle communication controller

battery technologies

UBS: EVs to reach profitability for automakers by 2021, surpass ICEs a few years later

Figure 79: OEM ROIC trend



Source: UBS estimates

battery technologies

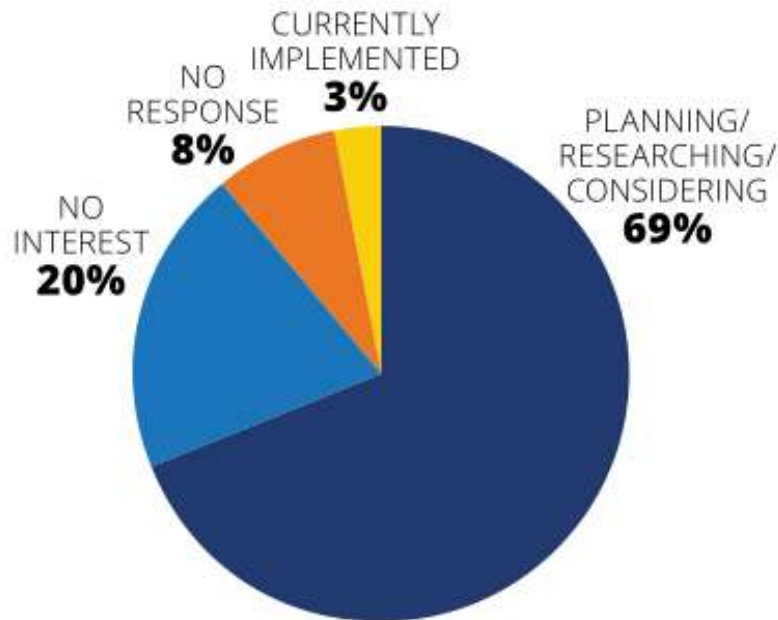
BNEF: Global battery manufacturing capacity set to more than double by 2021



grid management

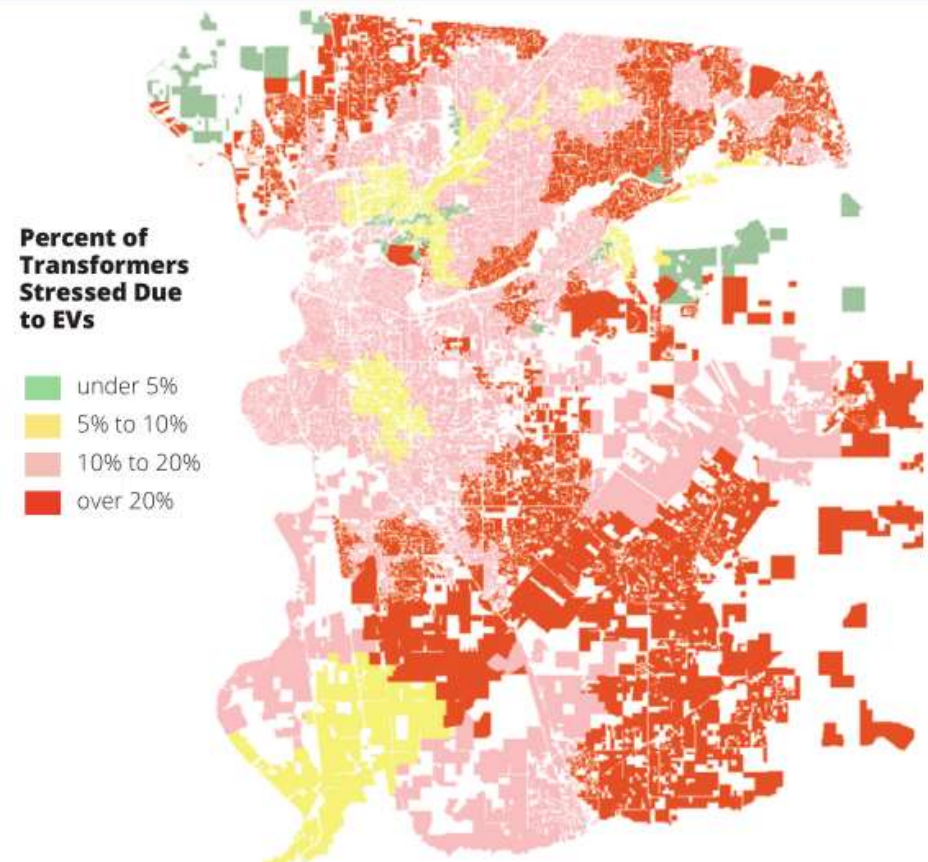
SEPA: Utilities are looking into management of EV charging to minimize stress to grid infrastructure

FIGURE 1: UTILITY INTEREST IN ELECTRIC VEHICLE MANAGED CHARGING DEMAND RESPONSE PROGRAMS



Source: Smart Electric Power Alliance, 2017

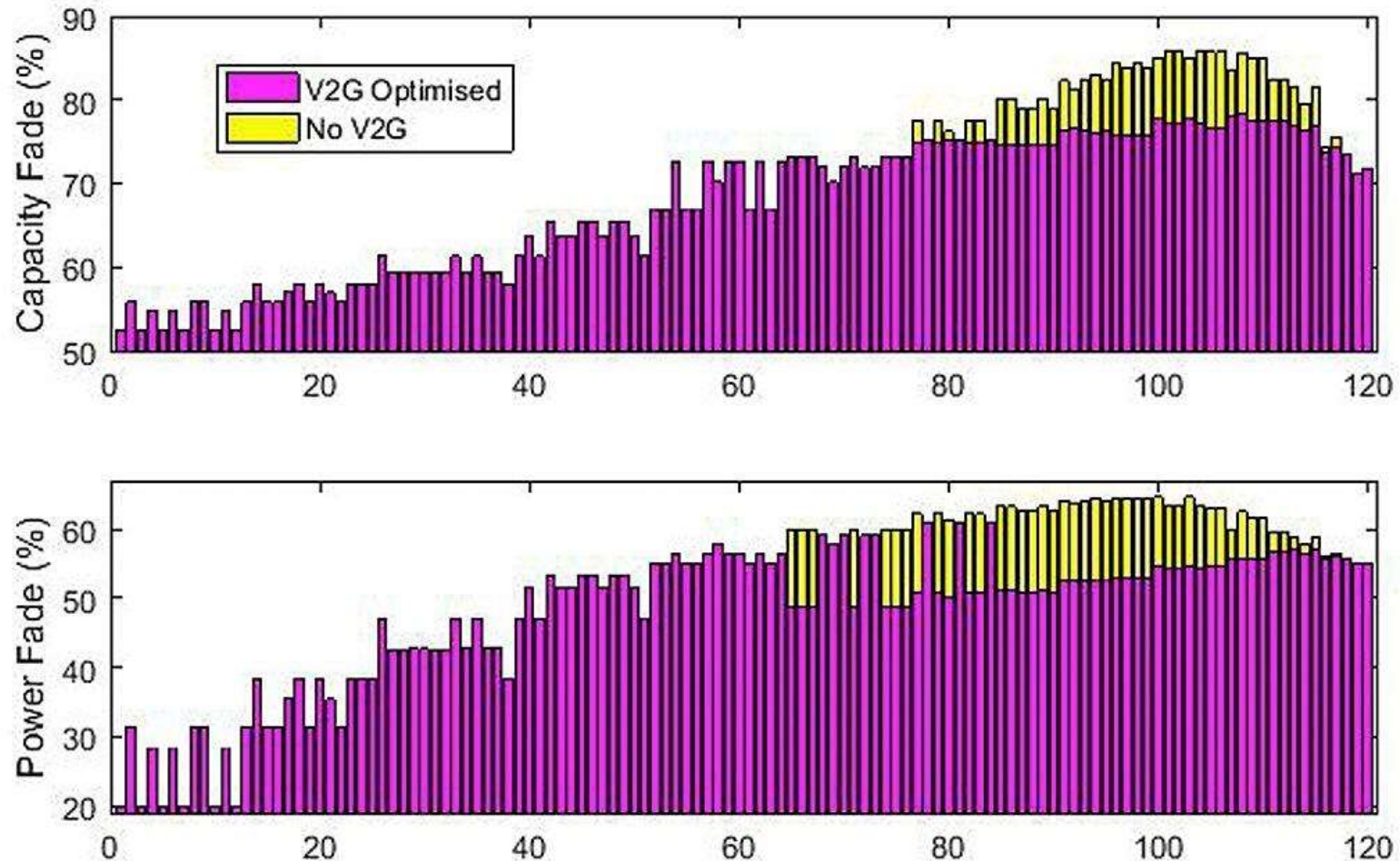
FIGURE 3: EV IMPACT ON TRANSFORMERS IN THE SACRAMENTO MUNICIPAL UTILITY DISTRICT SERVICE TERRITORY THROUGH 2030



Source: Smart Electric Power Alliance, Black & Veatch, and SMUD, 2017

grid management

U Warwick: Using PEVs for demand response for electric grid can potentially increase EV battery lifetime



CAVs

EIA: Automation and connectivity have potential to drastically change projections of LDV energy use

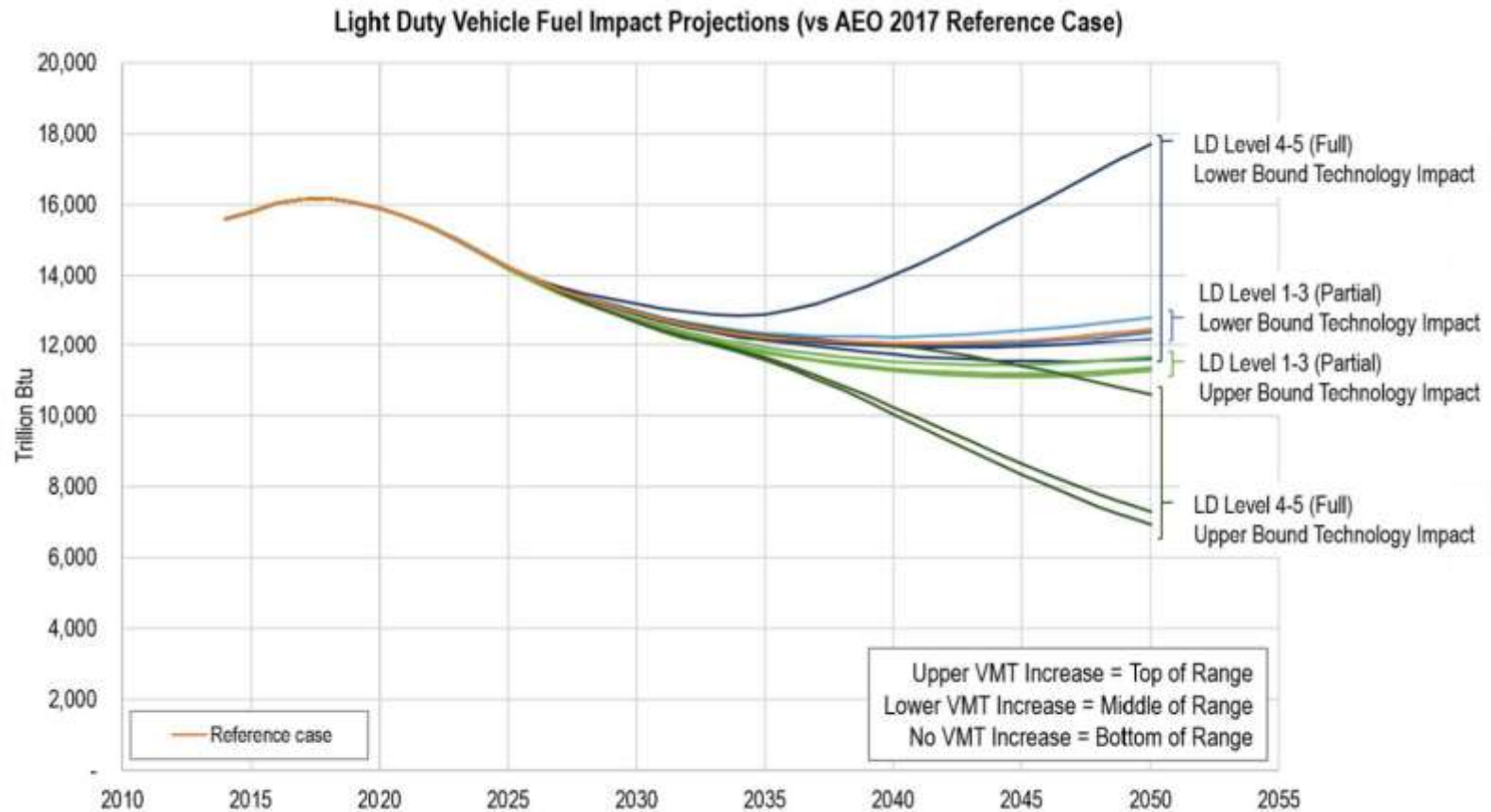
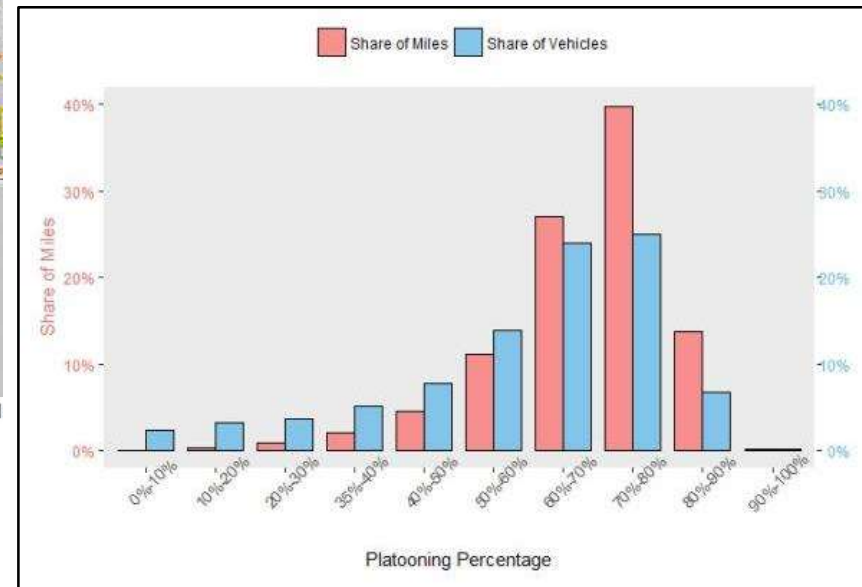
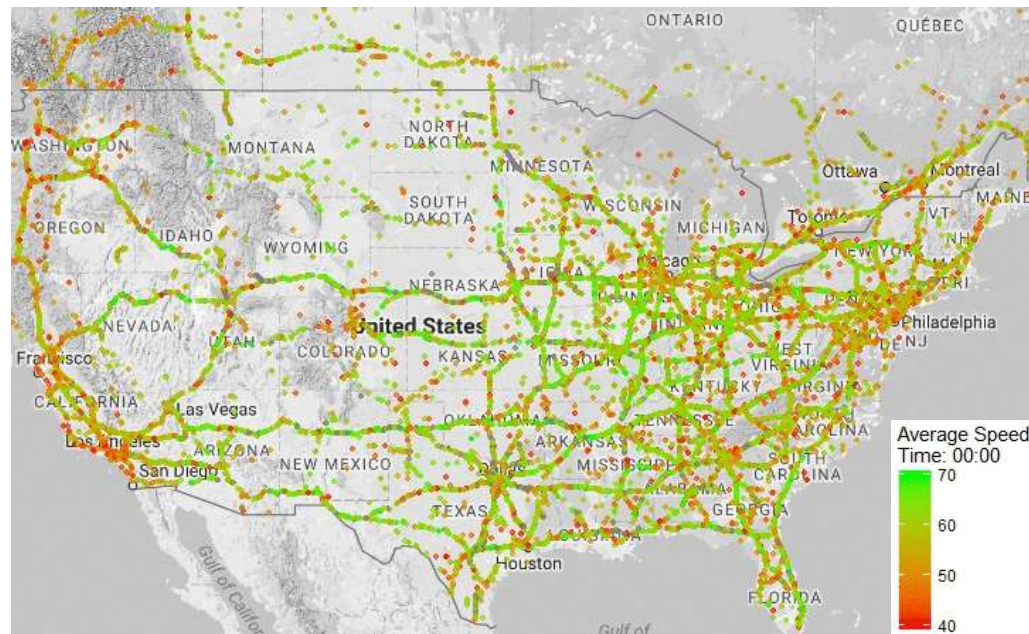


Figure 32. Light-duty vehicle fuel impact projections versus the EIA Annual Energy Outlook 2017 Reference Case

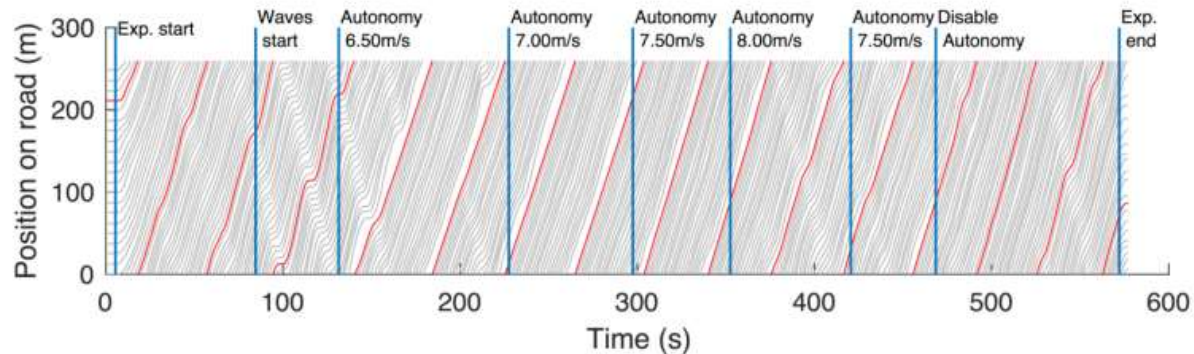
CAVs and platooning

NREL: Most platoonable HDV miles driven by small share of vehicles, indicating opportunities for early technology deployment; significant opportunities for platooning along corridors connecting urban areas

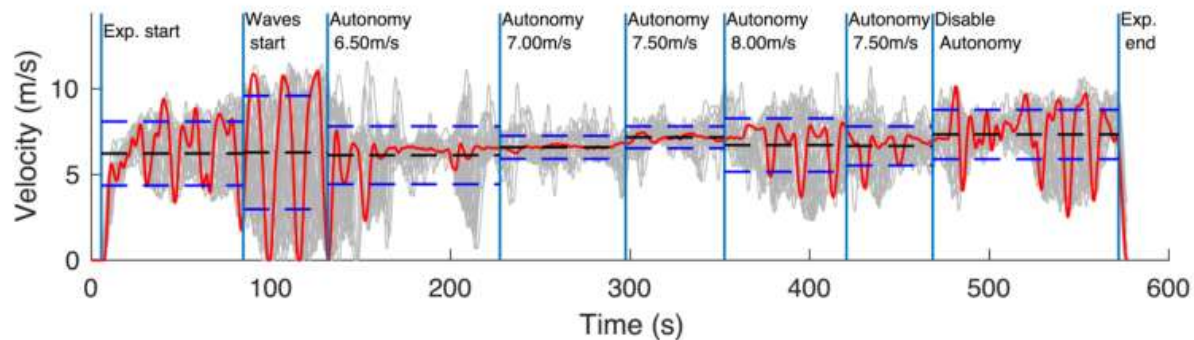


CAVs and traffic flow

UIUC: A single AV can dampen stop-and-go traffic waves to improve throughput and reduce total fuel use



(a) Trajectories of all vehicles in Experiment A, CAT Vehicle shown in red.



topics

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4 environmental studies

emissions

- > EIA: U.S. transportation sector CO₂ emissions increased in 2016
- > Google et al.: Mobile sensors can be used to detect air pollutants with high resolution
- > ICCT et al.: NO_x emissions are nearly 50% above regulatory limits worldwide

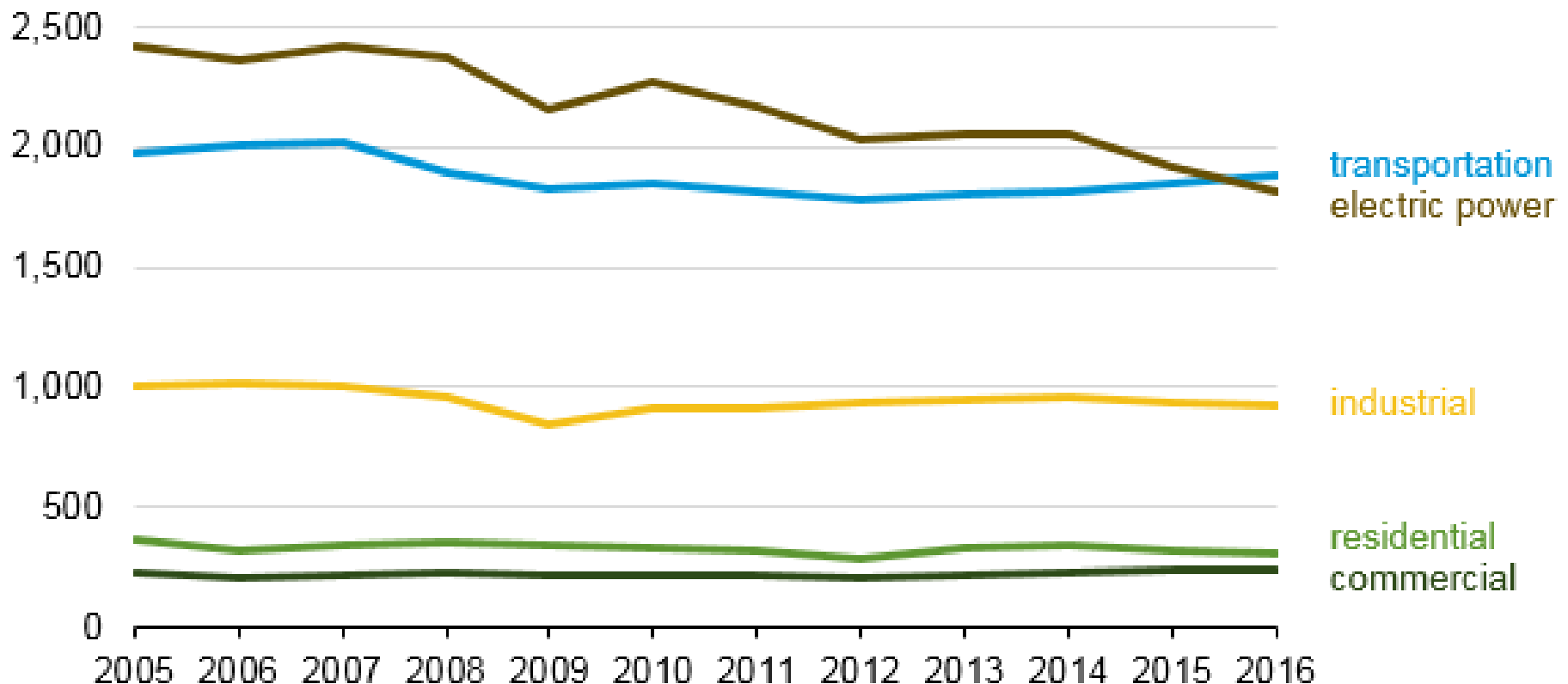
water consumption

- > ANL: Hydroelectricity is responsible for half of water consumption for electricity generation

CO₂ emissions

EIA: Transportation was only sector in which CO₂ emissions increased in United States in 2016

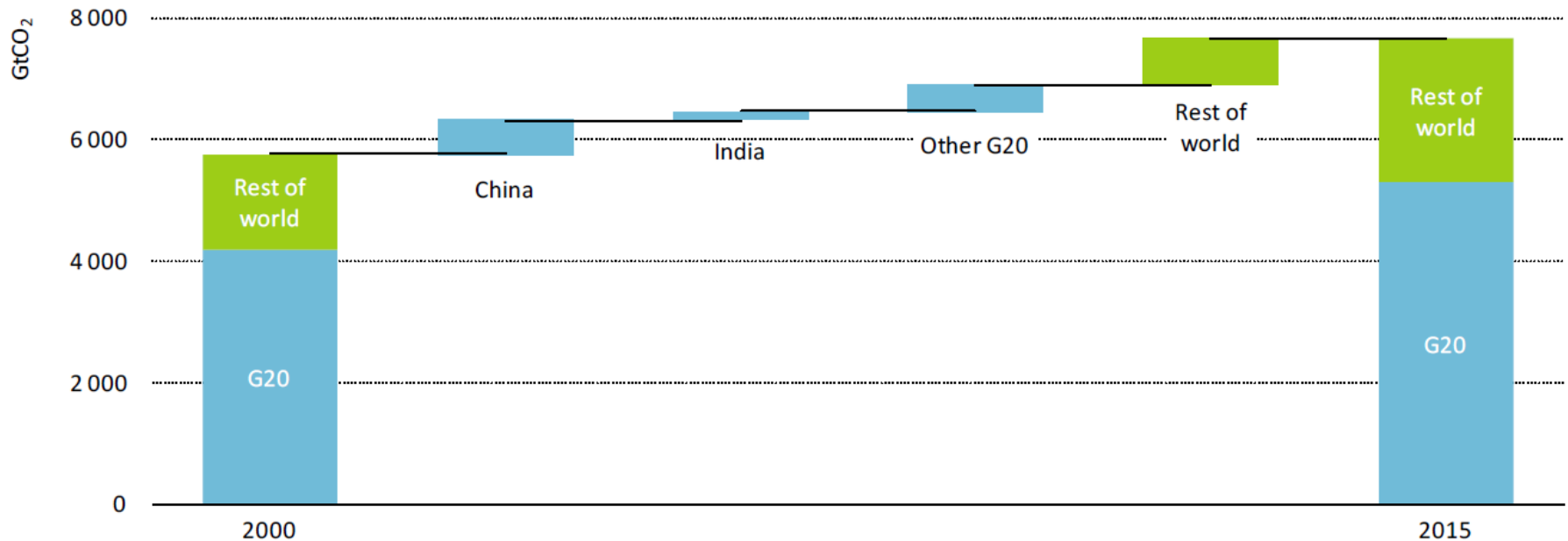
U.S. carbon dioxide emissions by sector (2005-16)
million metric tons



CO₂ emissions

IRENA: Countries outside the G20 account for a growing share of CO₂ emissions from transportation

Figure 1.18 • CO₂ emissions in the transport sector and contributions by region



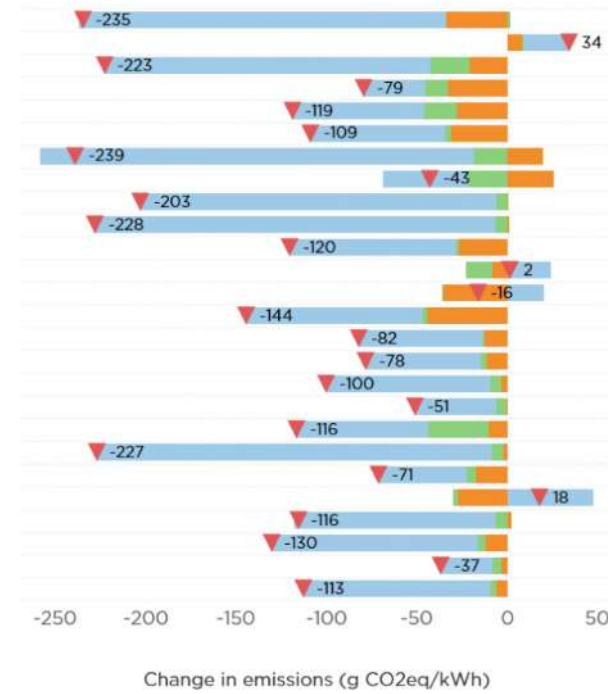
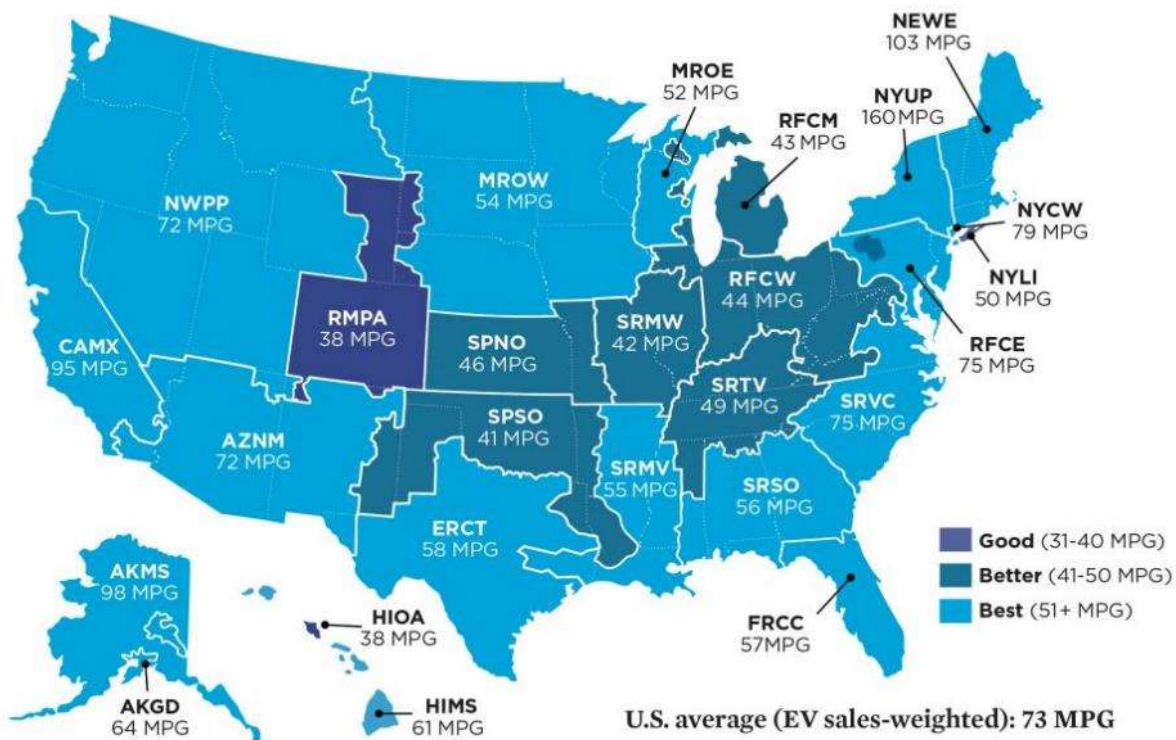
Source: IEA data and analysis.

Key message • Countries outside the G20 account for a growing share of CO₂ emissions from the transport sector.

CO₂ emissions

UCS: Reduced emissions from electric grid lowers emissions from EVs; average EV comparable to 73 mpg ICE

Electric Vehicle Global Warming Pollution Ratings and Gasoline Vehicle Emissions Equivalents by Electricity Grid Region



emissions

EDF, U Texas, Google: Mobile sensors can be used to determine pollutants with high spatial resolution

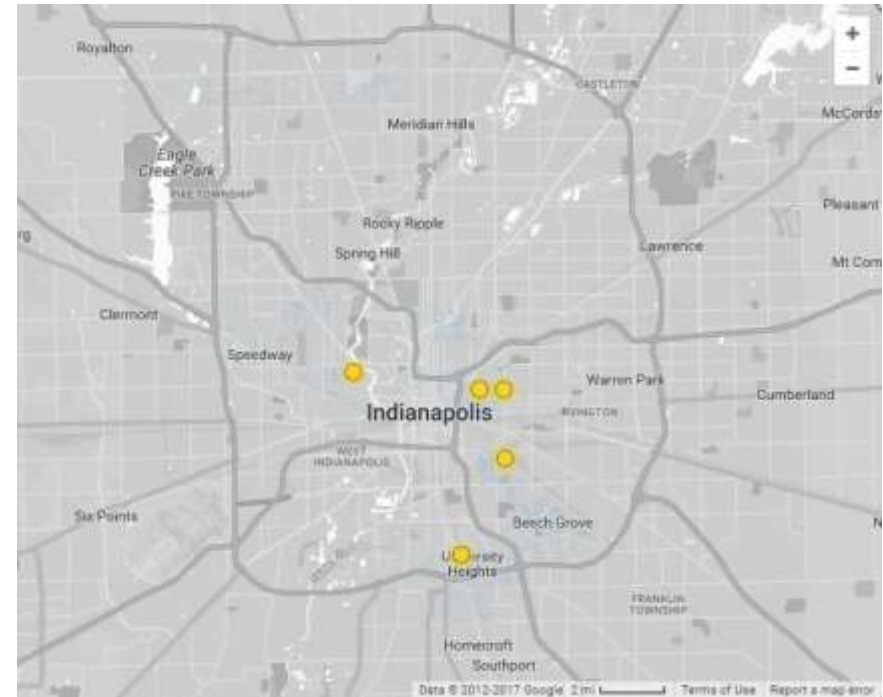


emissions

EDF, CSU, Google: Newer NG infrastructure less prone to methane leaks



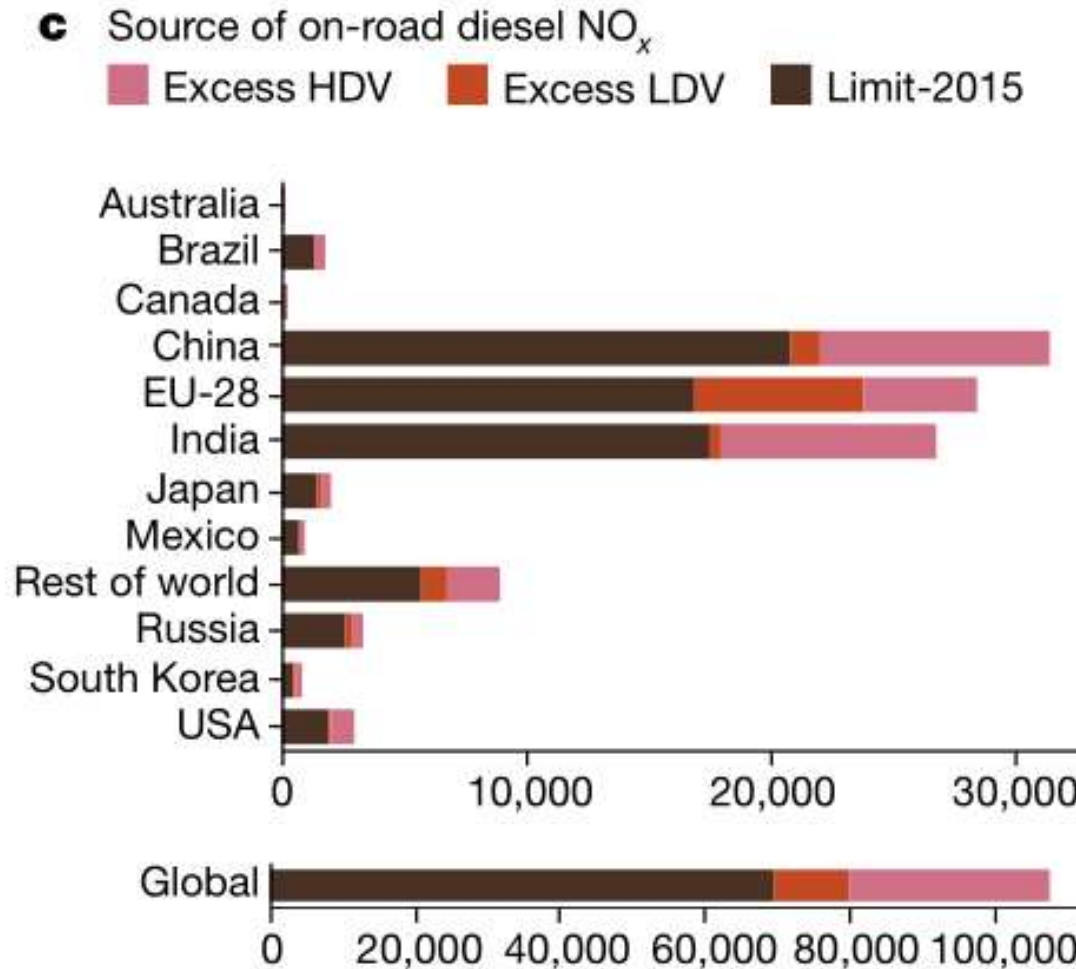
Methane leaks detected in Boston



Methane leaks detected in Indianapolis

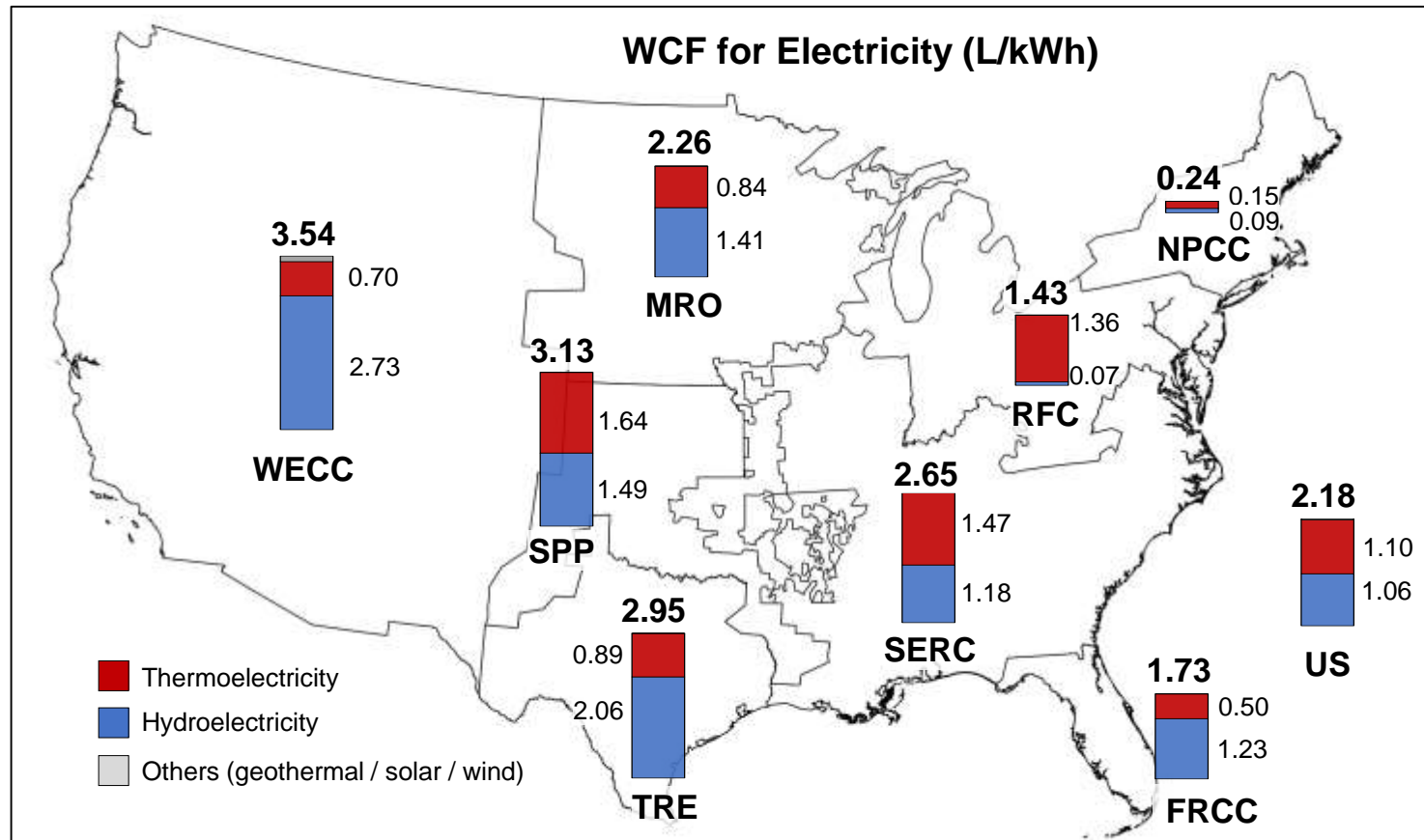
emissions

ICCT: Emissions beyond regulatory limits responsible for about 1/3 of global on-road diesel NO_x emissions



water consumption

ANL: Hydroelectricity is responsible for 50% of U.S. water consumption for electricity generation, only 6.3% of total U.S. electricity generation



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5 consumer & opinion surveys

purchasing behavior

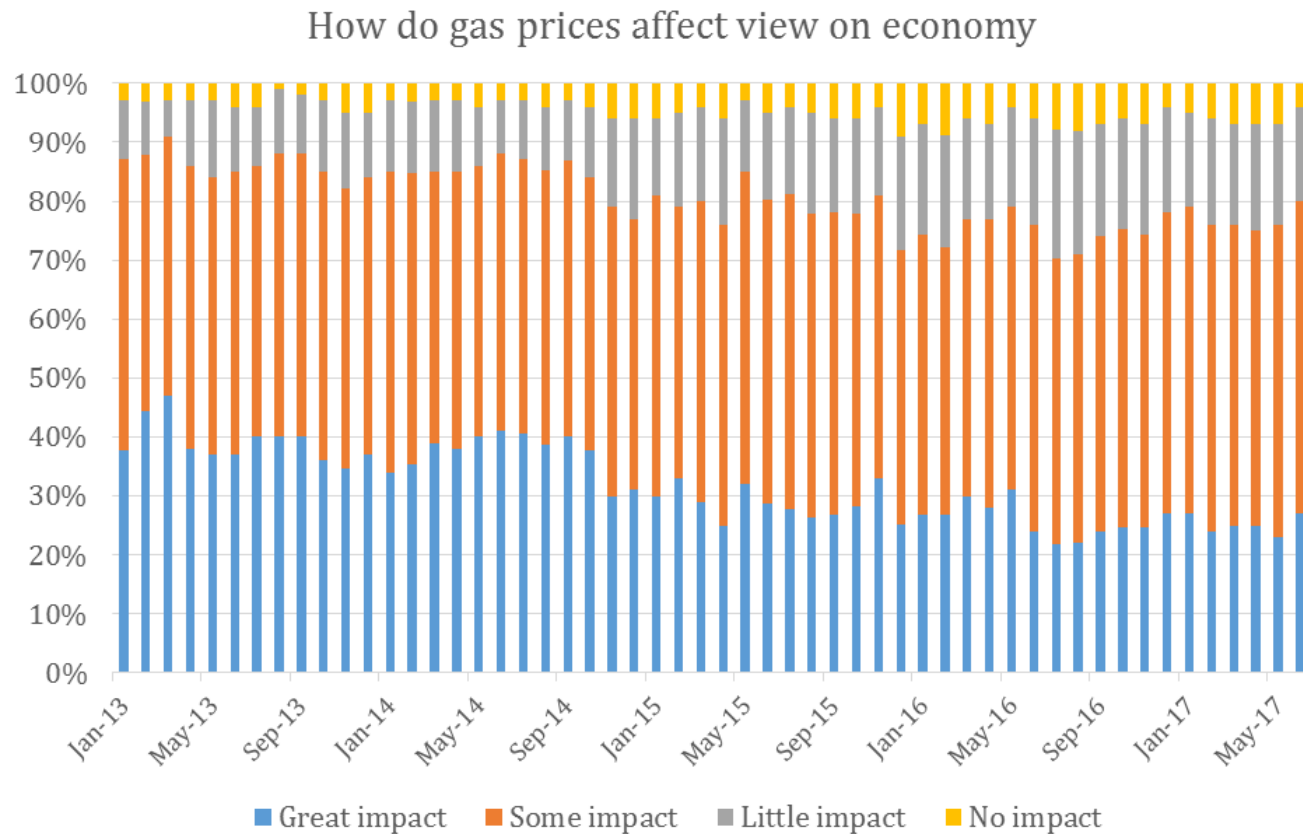
- > NACS: Gasoline prices are less important in consumer perceptions of economy
- > AAA: Refueling and vehicle costs are viewed as top reasons to not buy EV

CAVs technologies

- > JD Power: Younger people more accepting of driving assistance technologies
- > INRIX: Most people expect CAVs by 2025
- > Deloitte: In some countries, tech companies are more trusted to bring CAVs to market, in others, OEMs

fuel prices

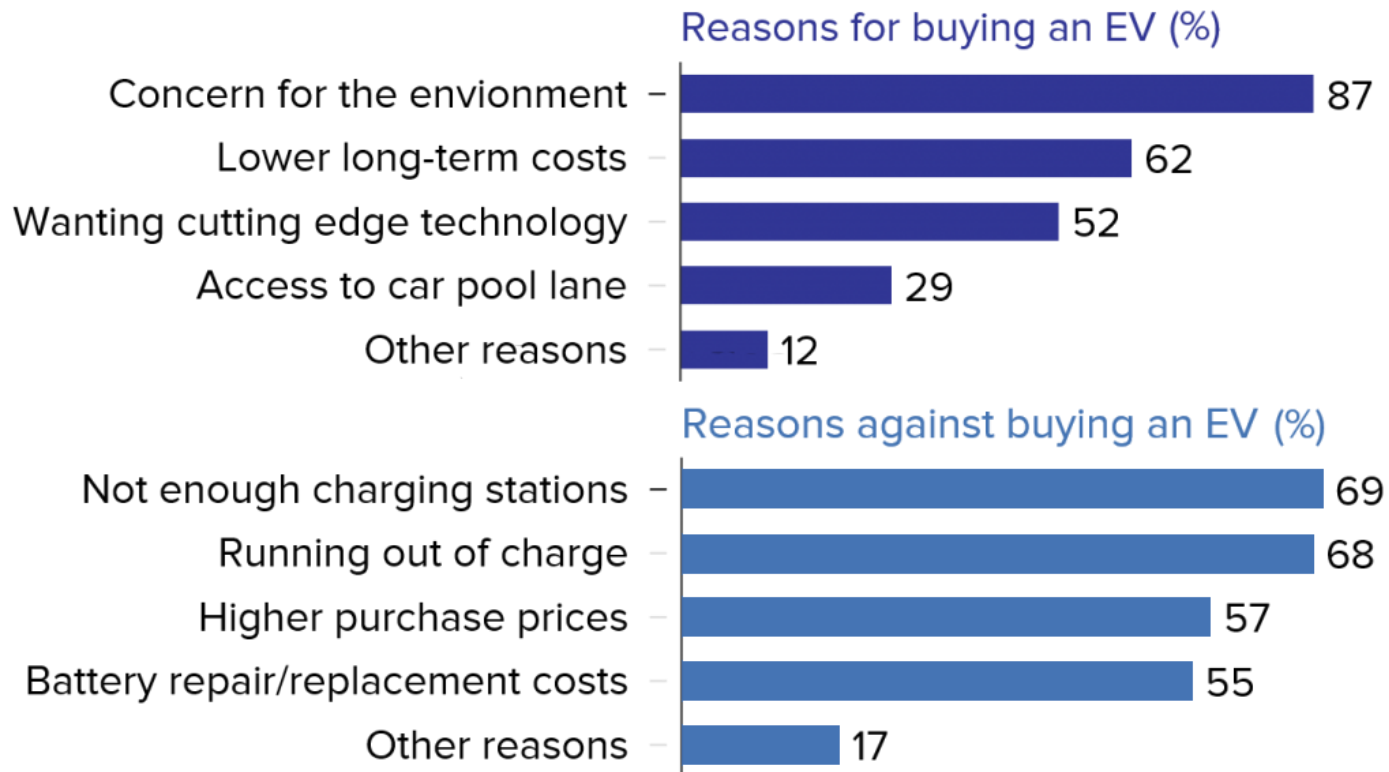
NACS: Gasoline prices playing a decreasing role in consumer perception of broader economy



EV sentiments

AAA via MarketMogul: Refueling and costs are the top reasons stated against buying an EV

Survey: The Pros and Cons of Electric Cars

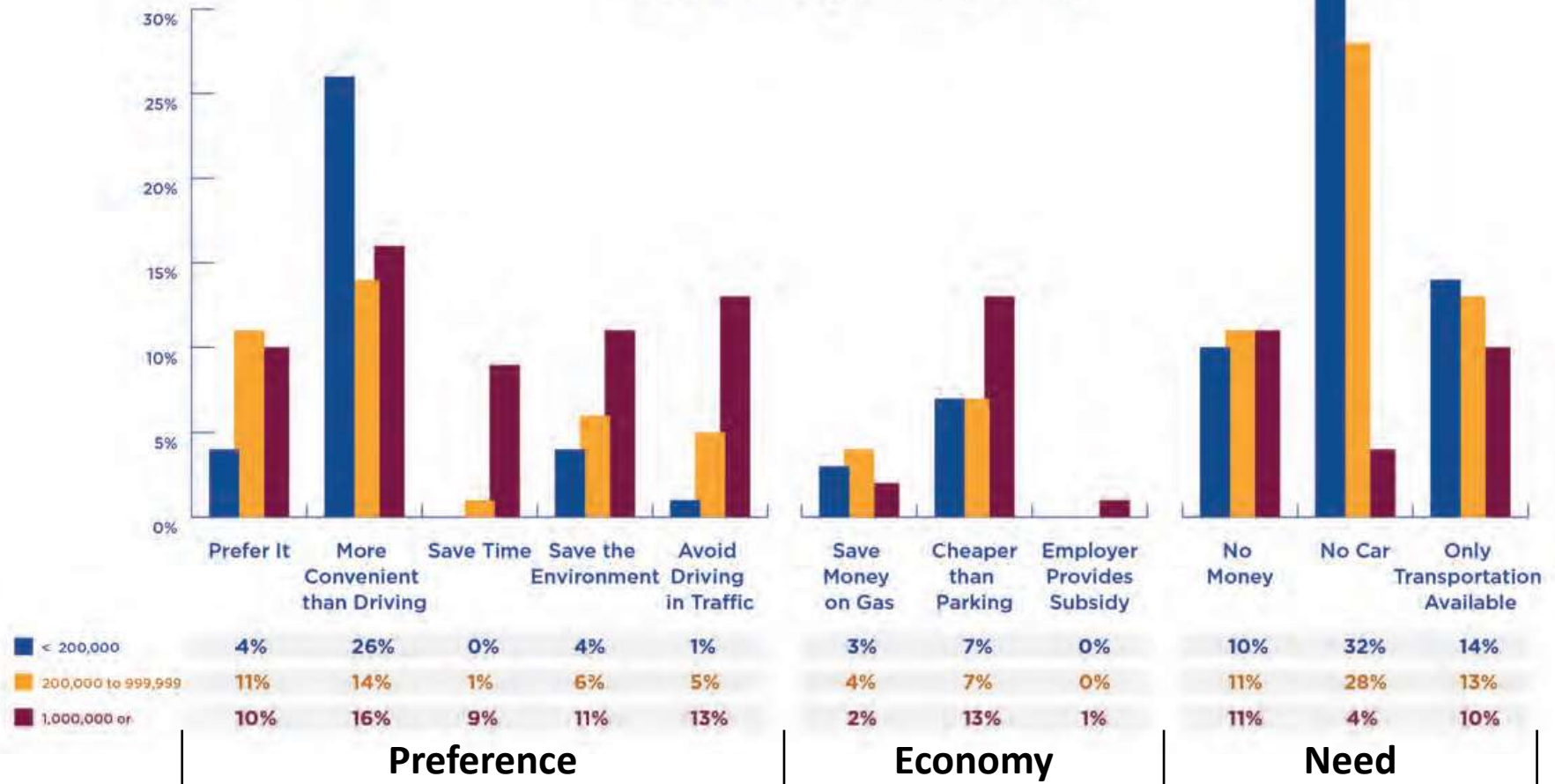


 The Market Mogul | Data: American Automobile Association

mode choice

➤ APTA: Many people take transit out of necessity, but many take out of preference as well

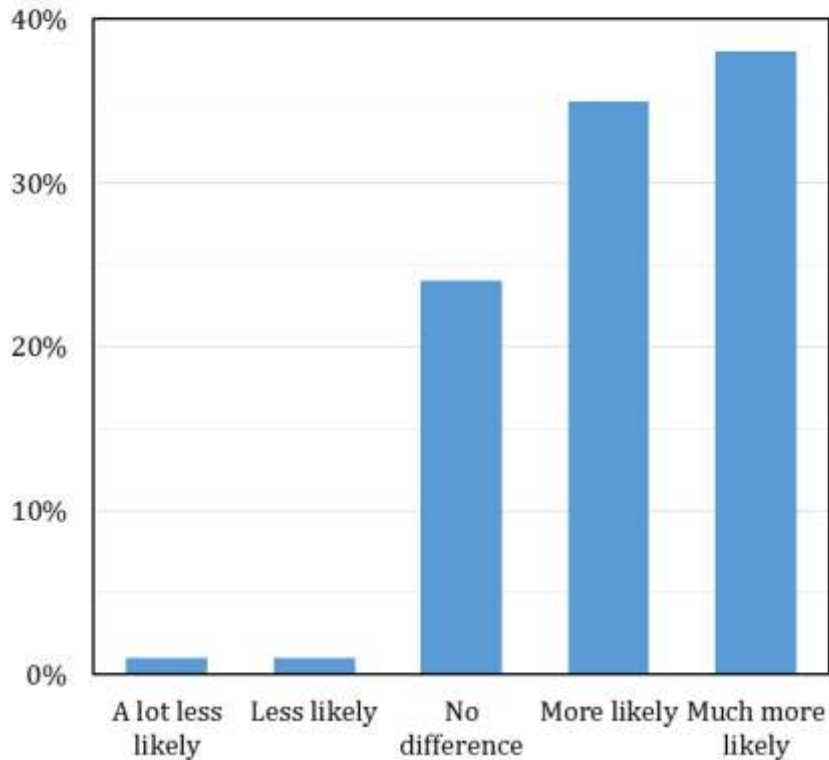
Stated Reason for Using Transit



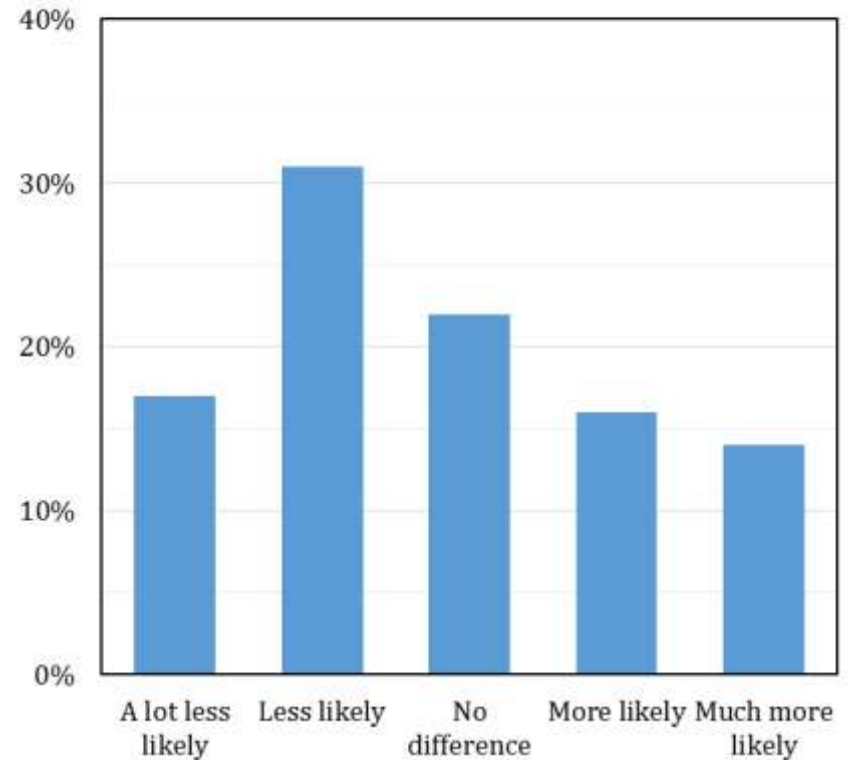
mode choice

INRIX: Availability of parking changes people's likelihood to make a trip

If You Knew That Parking Was Available
How Would That Impact Your Decision To
Drive?

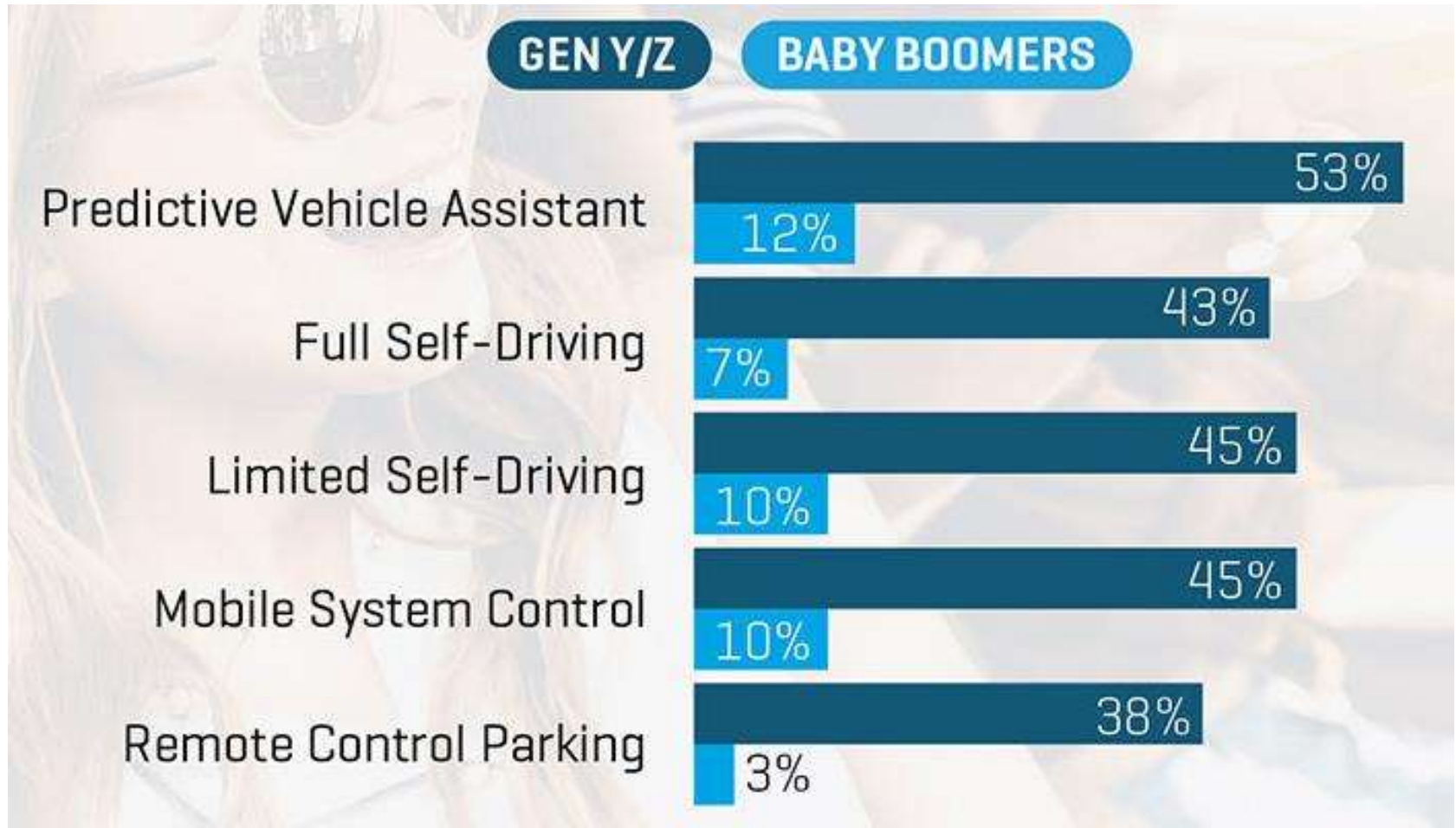


If You Knew That Parking Was NOT
Available How Would That Impact Your
Decision to Drive?



CAV perceptions

JD Power: Younger generation is much more likely to want assistive driving technologies

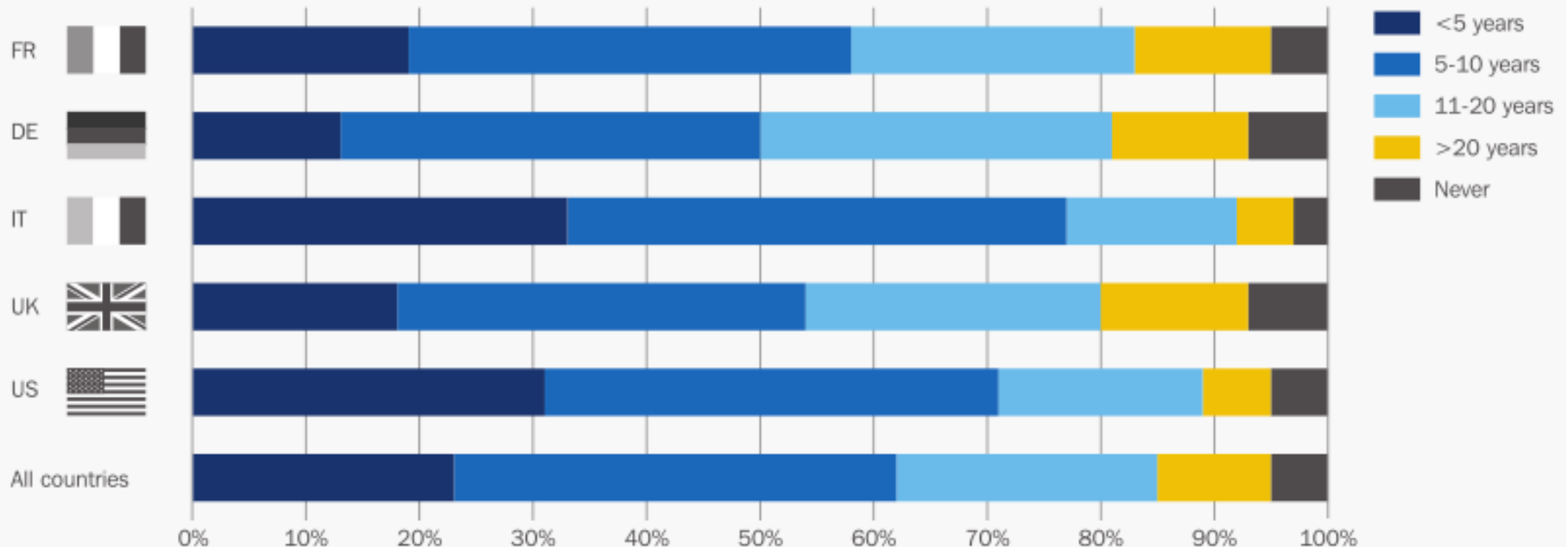


CAV perceptions

INRIX: Most people think we will be driving AVs by 2025

Figure 19: When will driverless vehicles be widely available?

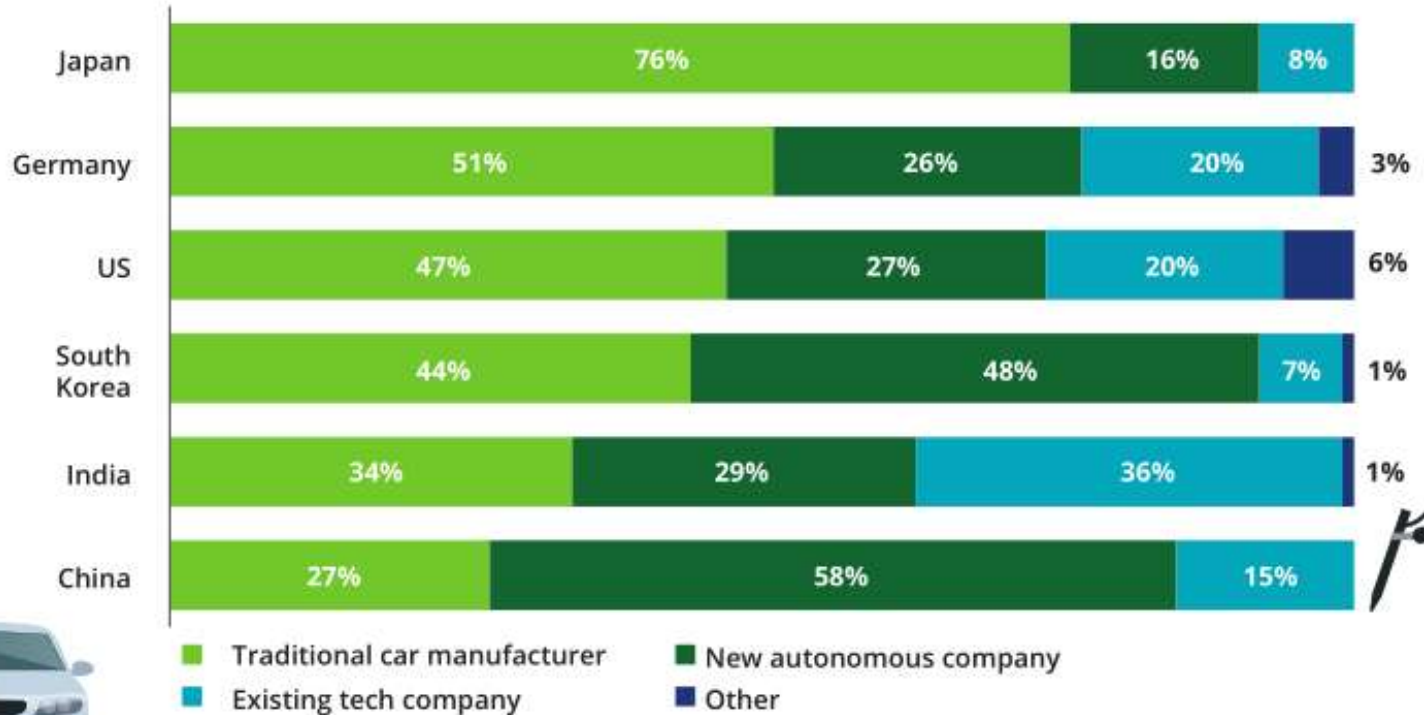
Italians are slightly more optimistic about AVs but about 50% of people think we will be driving AVs by 2025



CAV perceptions

Deloitte: Opinions on most trusted sector to lead AVs different across the globe

Types of companies consumers trust most to bring fully autonomous vehicles to market



Source: Deloitte Global Automotive Consumer Study

CAV perceptions

INRIX, SMMT: Stress relief and improved mobility are popular benefits of CAVs

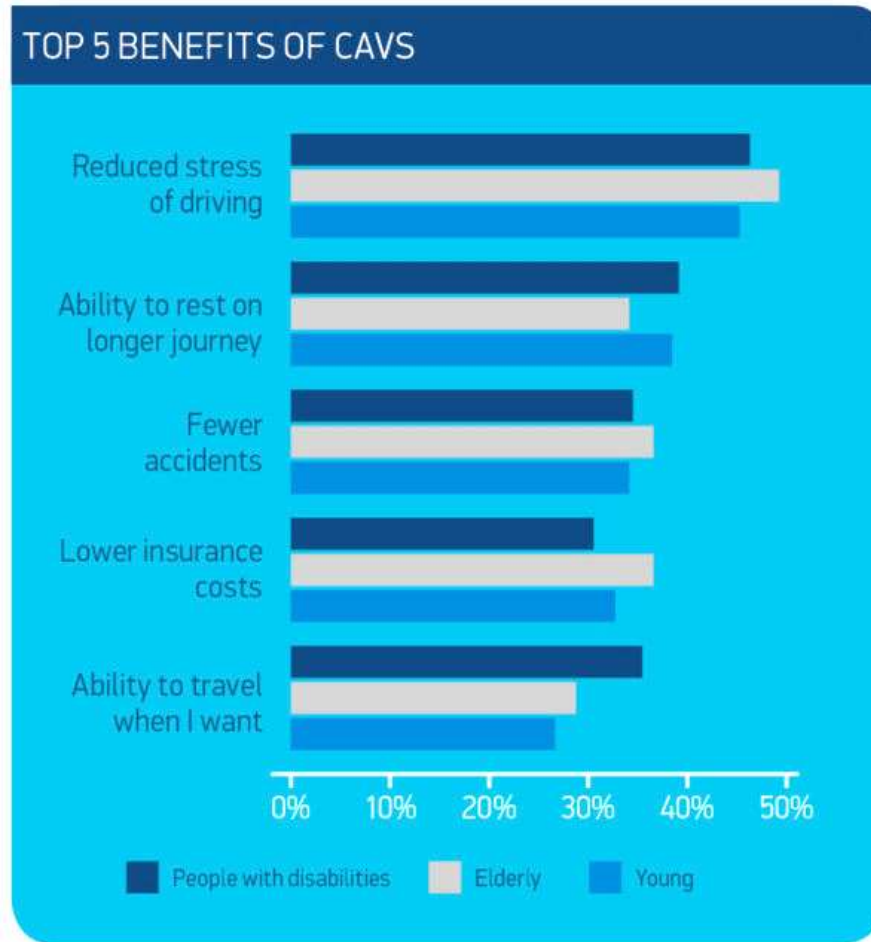
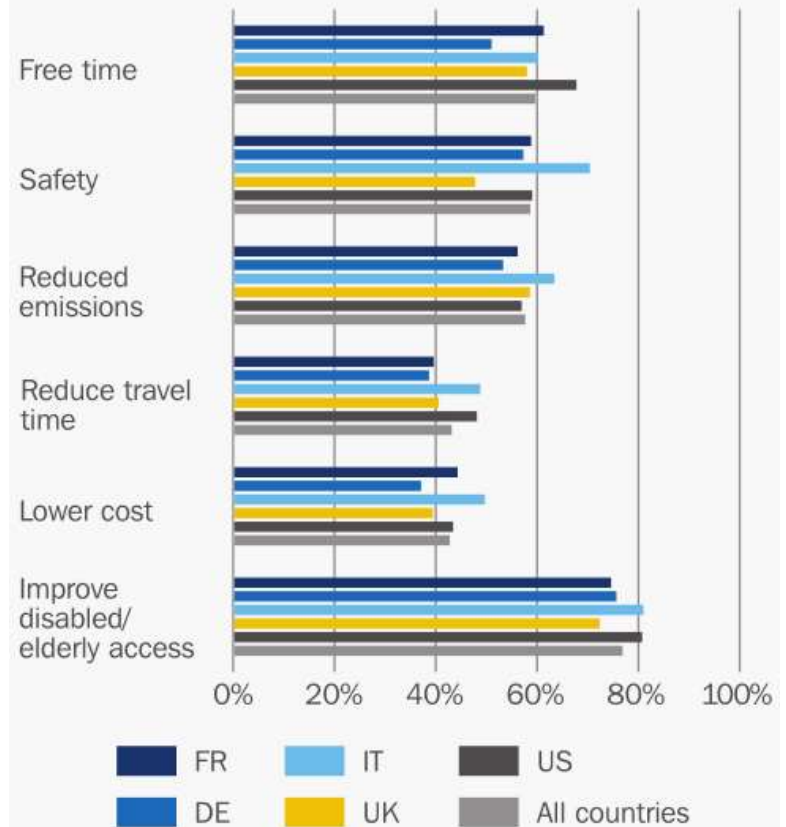


Figure 26: The benefits of AVs are clear
Improving access most popular benefit but all drivers agree that increased free time and safety are obvious benefits



CAV perceptions

➤ Erie Insurance: Drivers are looking forward to benefits of additional free time in fully self-driving cars



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6 policy & business studies **qar**
outline

6 policy & business studies

employment

- > FOTW: Production and manufacturing comprise 1/3 of motor vehicle jobs
- > FOTW: 11% of motor vehicle jobs focus on alternative fuels/drivetrains
- > UBS: Dealerships get most of their profits from service and parts

regulations standards

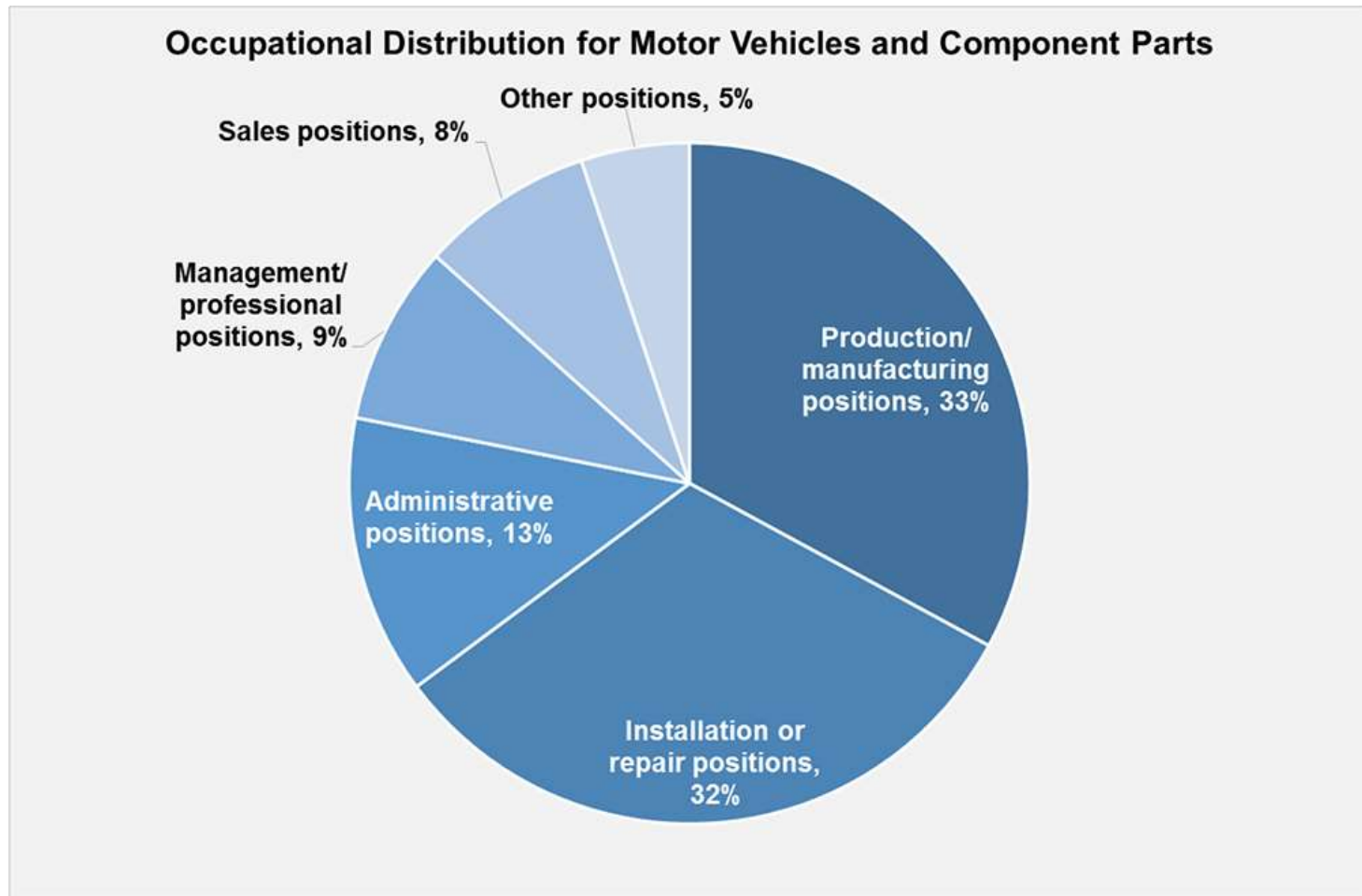
- > ICCT: GHG regulations are tightening worldwide
- > CARB: ZEV mandates are in effect through 2025, plan to make more stringent afterwards

mobility as a service

- > Brookings: “non-employee” drivers growing rapidly
- > RethinkX: Transportation-as-a-service can cause EVs to be cheaper than ICEs and drastically change vehicle sales

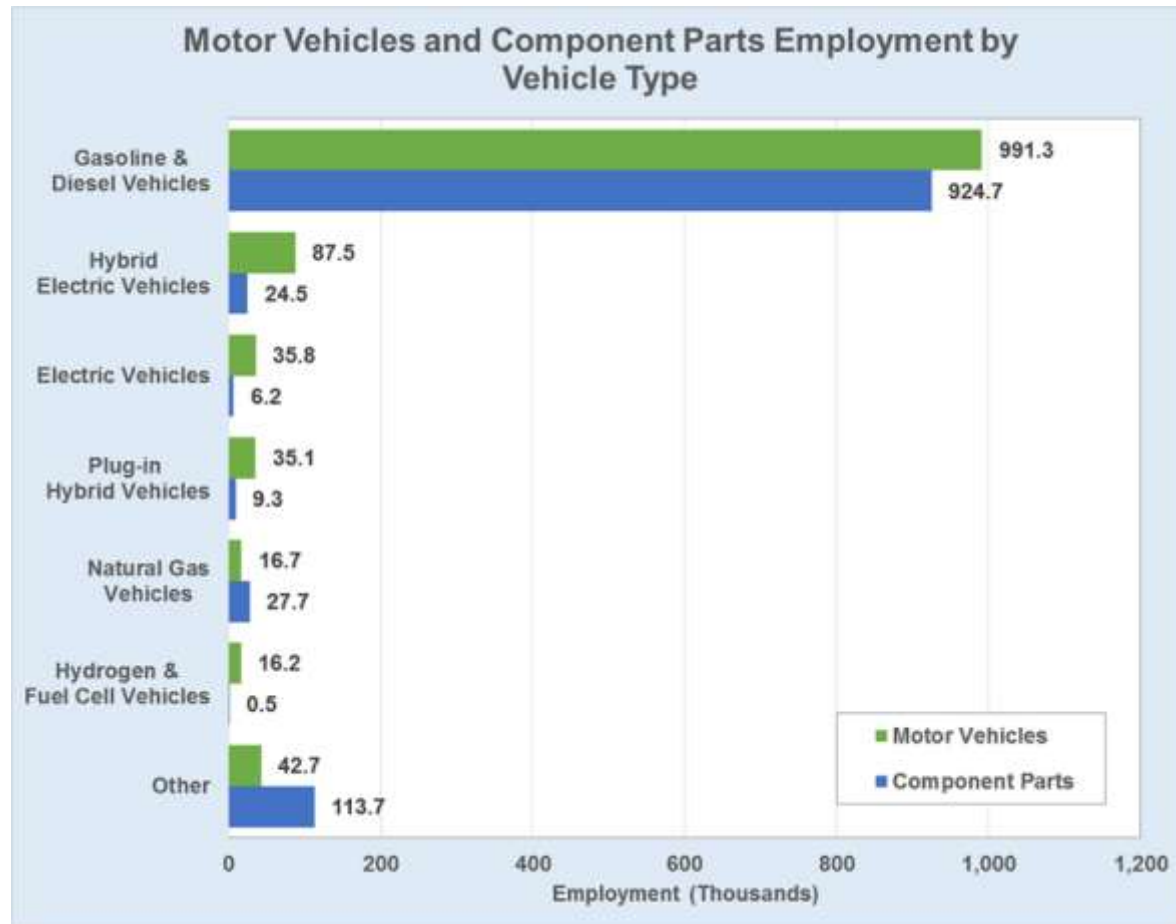
employment

FOTW: Production and manufacturing comprise one-third of motor vehicle jobs



employment

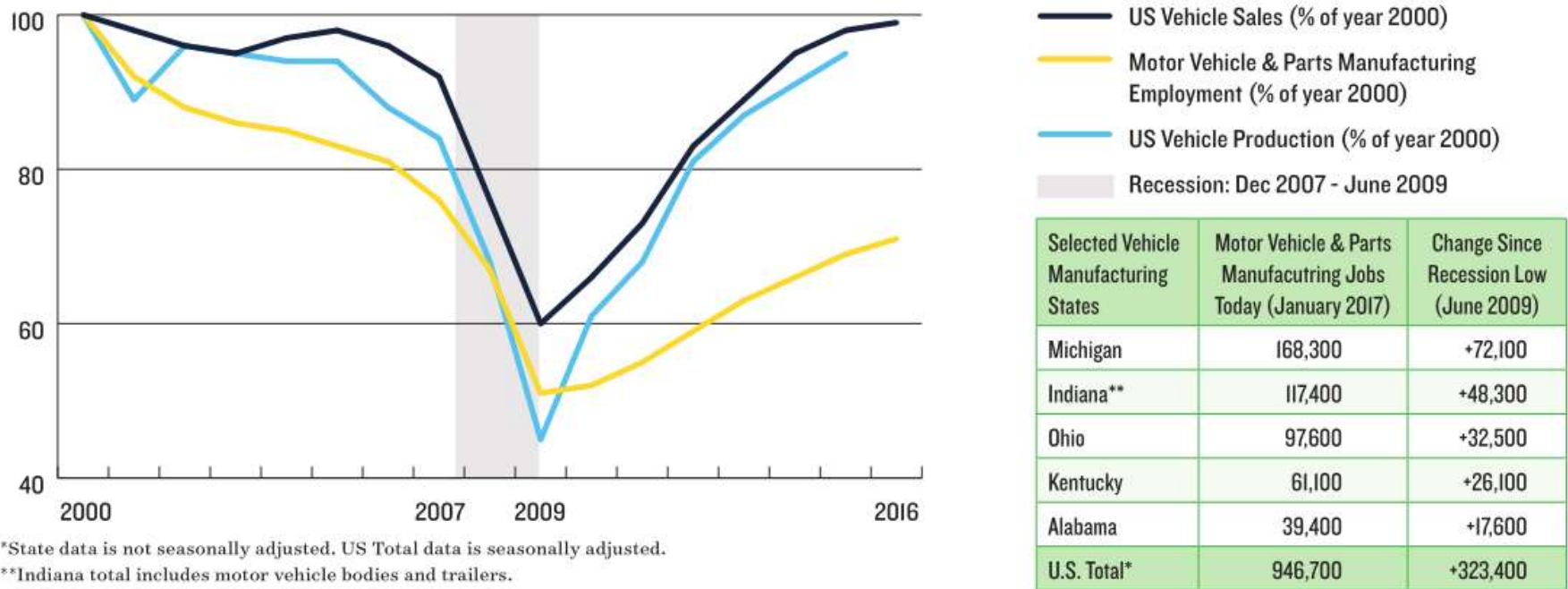
FOTW: 11% of motor vehicle-related jobs focus on alternative fuel and drivetrain vehicles



employment

NRDC: Motor vehicle production and sales have nearly reached 2000 levels in U.S., while employment is still down 30%

FIGURE I: A FOCUS ON BOTH DOMESTIC MANUFACTURING AND TECHNOLOGY LEADERSHIP WILL BE CRITICAL TO ONGOING JOB GAINS



*State data is not seasonally adjusted. US Total data is seasonally adjusted.

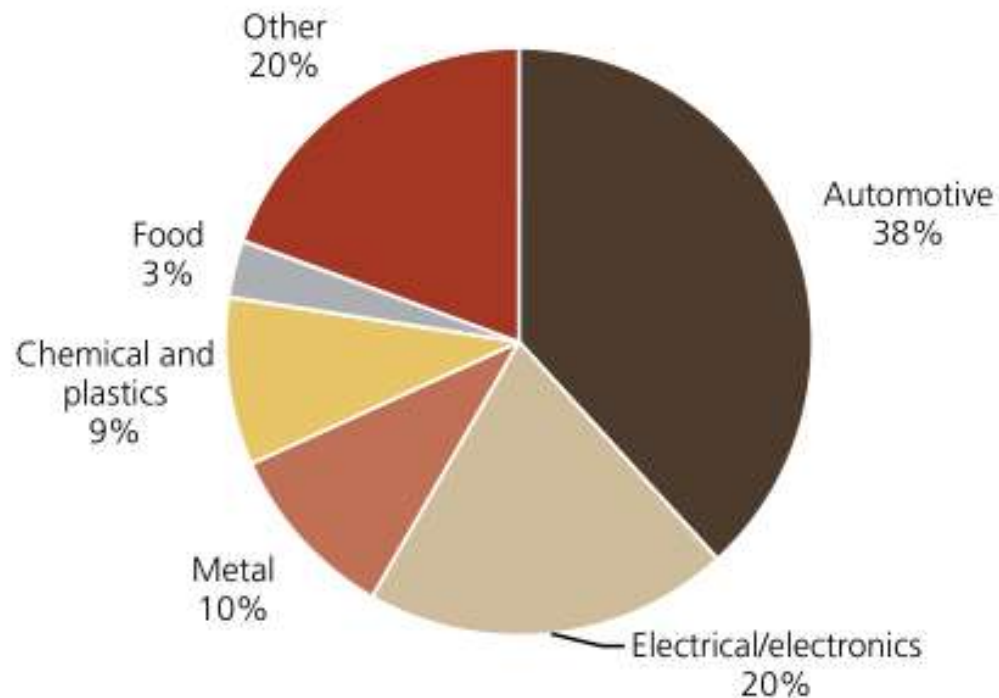
**Indiana total includes motor vehicle bodies and trailers.

Sources: Employment, US Bureau of Labor Statistics. Sales, Auto Alliance. Production, DOT RITA.

employment

UBS: Auto industry accounts for over one-third of industrial robots in world

Figure 74: The Automotive sector accounts for 38% of the worldwide operational stock of industrial robots (year end 2015)

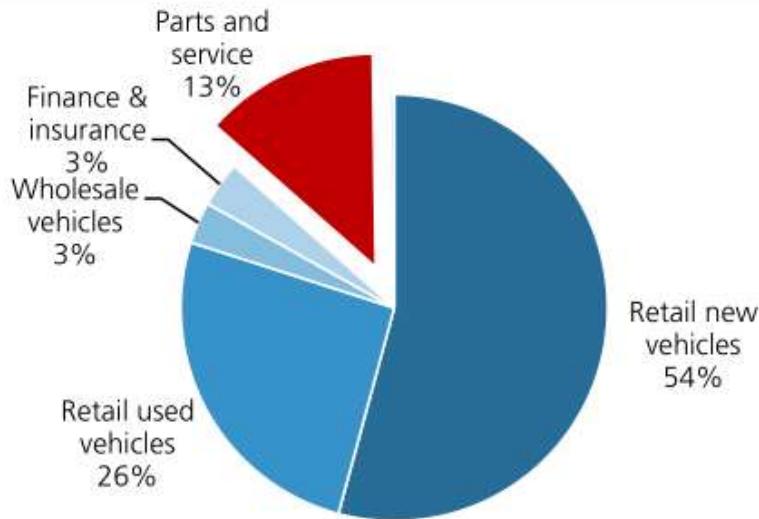


Source: International Federation of Robotics

dealerships

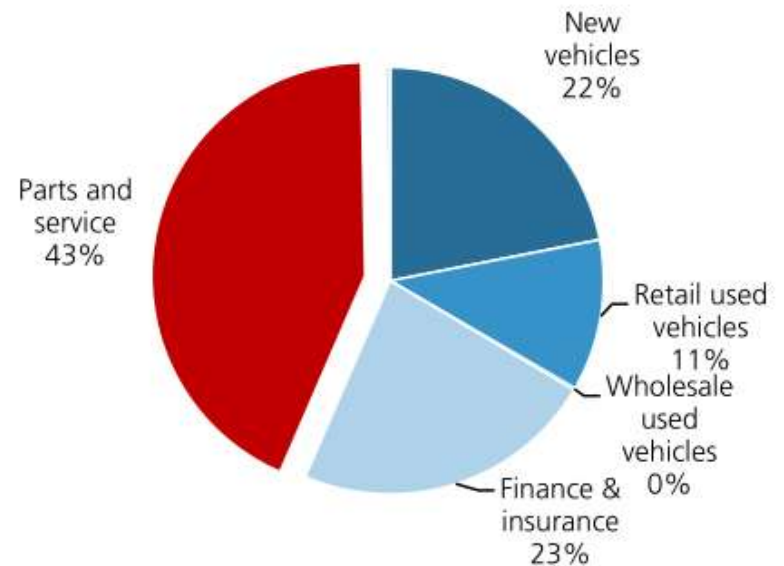
UBS: While new vehicles bring majority of revenue, dealerships get most profit from parts and service

Figure 97: Dealership revenue mix



Source: UBS (based on average numbers for AutoNation, Penske, SonicAutomotive, Group1, Asbury and Lithia)

Figure 98: Dealership gross profit mix



Source: UBS (based on average numbers for AutoNation, Penske, SonicAutomotive, Group1, Asbury and Lithia)

emissions standards

ICCT: Standards for CO₂ emissions from light-duty vehicles are tightening in many countries worldwide

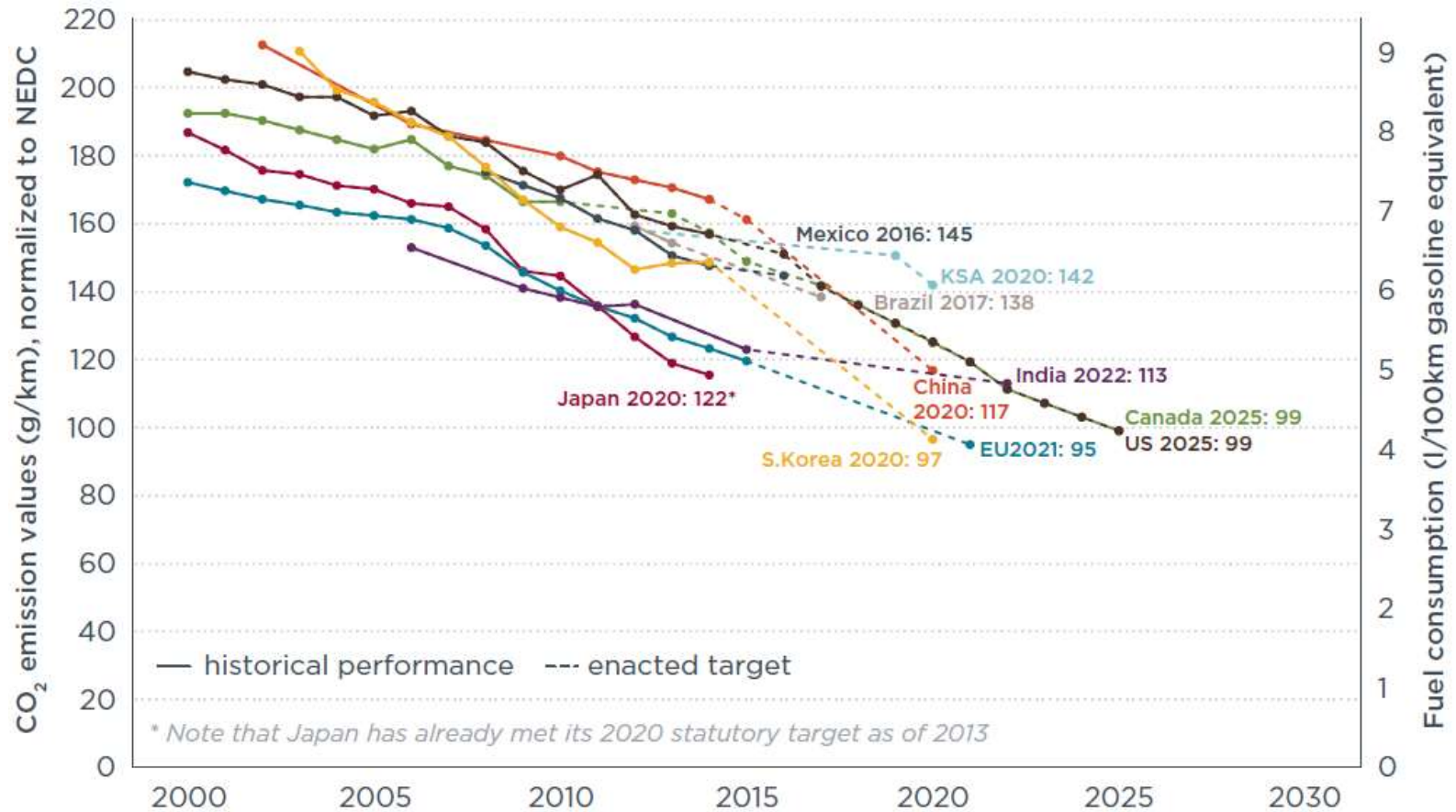
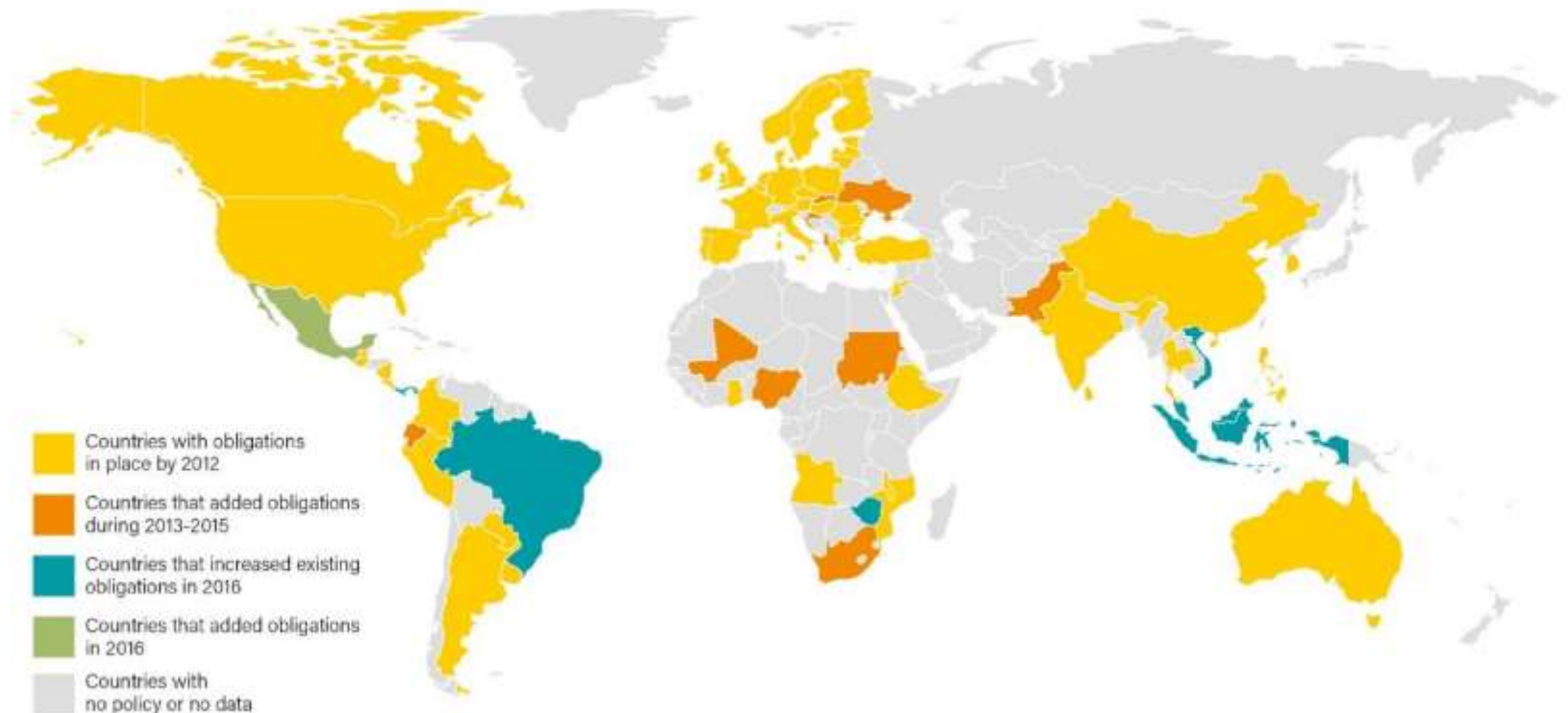


Figure 3. Comparison of global CO₂ regulations for new passenger cars.⁸

biofuels

REN: Many countries have biofuels obligations for transportation fuel, many adding or increasing obligations as well

Countries with Biofuels Obligations for Transport, 2016



ZEV mandates

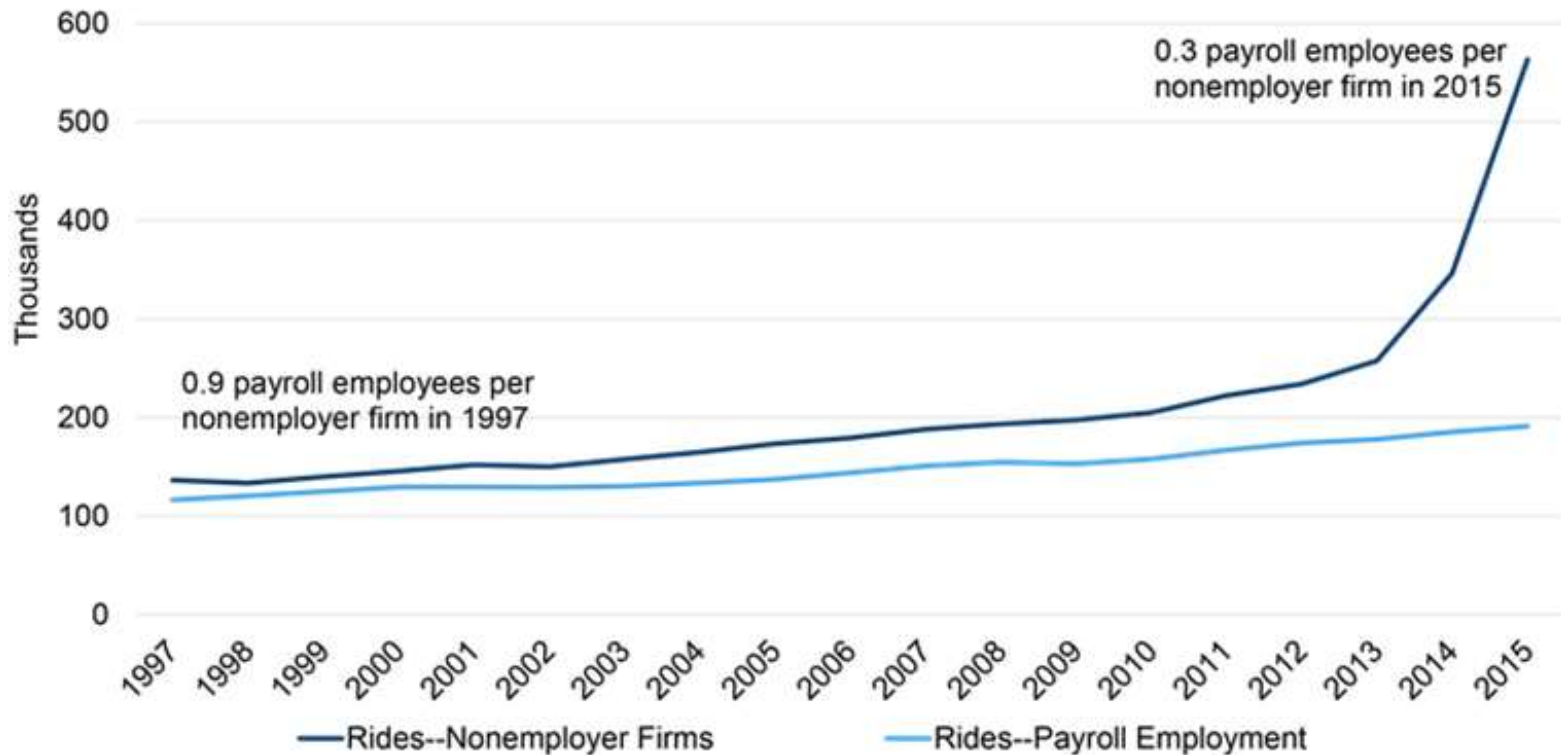
CARB: ARB voted to continue GHG and ZEV programs for LDV through 2025, and increase thereafter



mobility-as-a-service

Brookings: Number of “nonemployee” drivers for ground transportation doubled from 2013 to 2015

Nonemployer firms and employment in select passenger ground transportation industries (1997-2015, United States)



Source: Brookings Analysis of Census Bureau and Moody's data

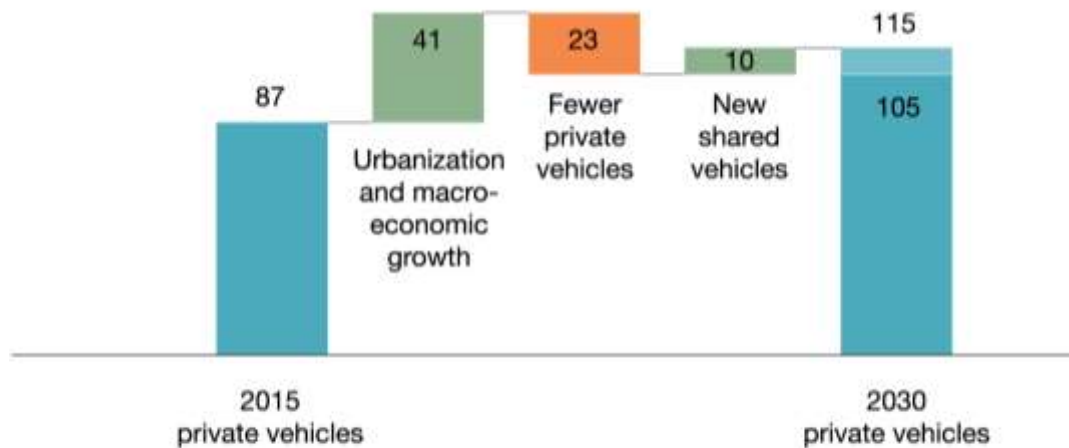
Note: Includes NAICS code industries 4853 and 4859

B Metropolitan Policy Program
at BROOKINGS

mobility-as-a-service

McKinsey: Vehicle sharing may partially offset increase in vehicle sales due to urbanization; purpose-built vehicles may be cheaper for OEM than today's vehicles

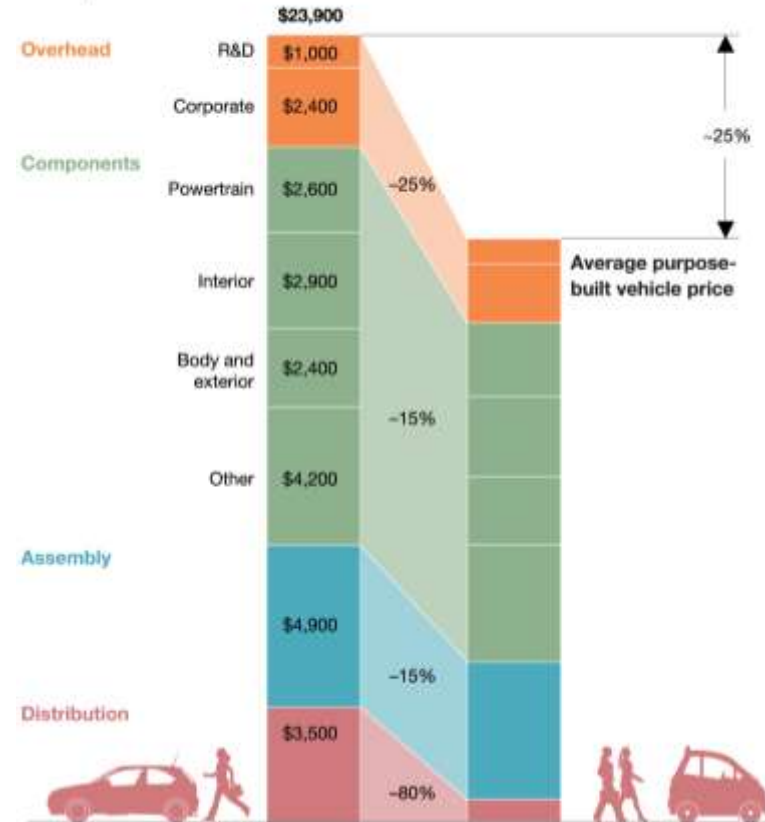
Annual global vehicle sales in high-disruption scenario, millions of units



Compound annual growth rate, %



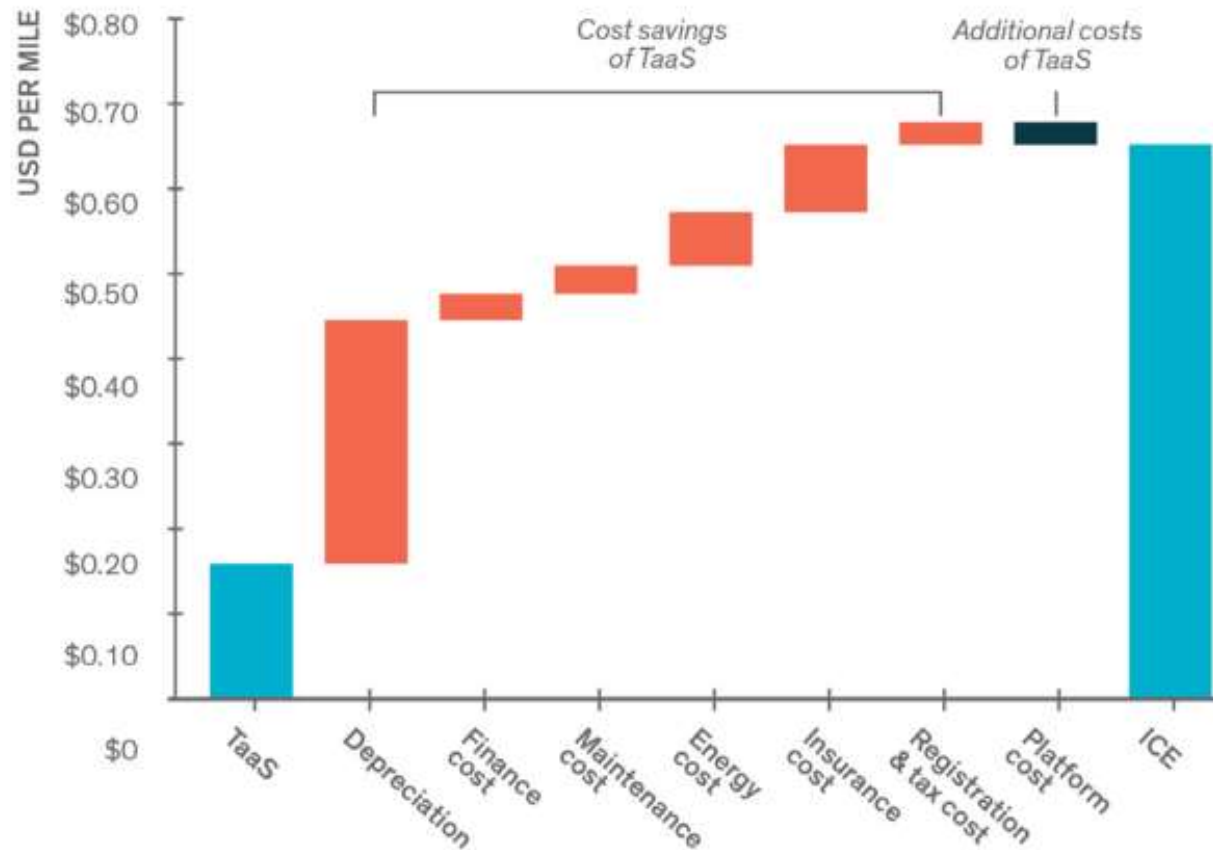
Average internal-combustion-engine vehicle price



mobility-as-a-service

➤ RethinkX: TaaS EV CAVs can potentially be far cheaper than personally owned ICE vehicles

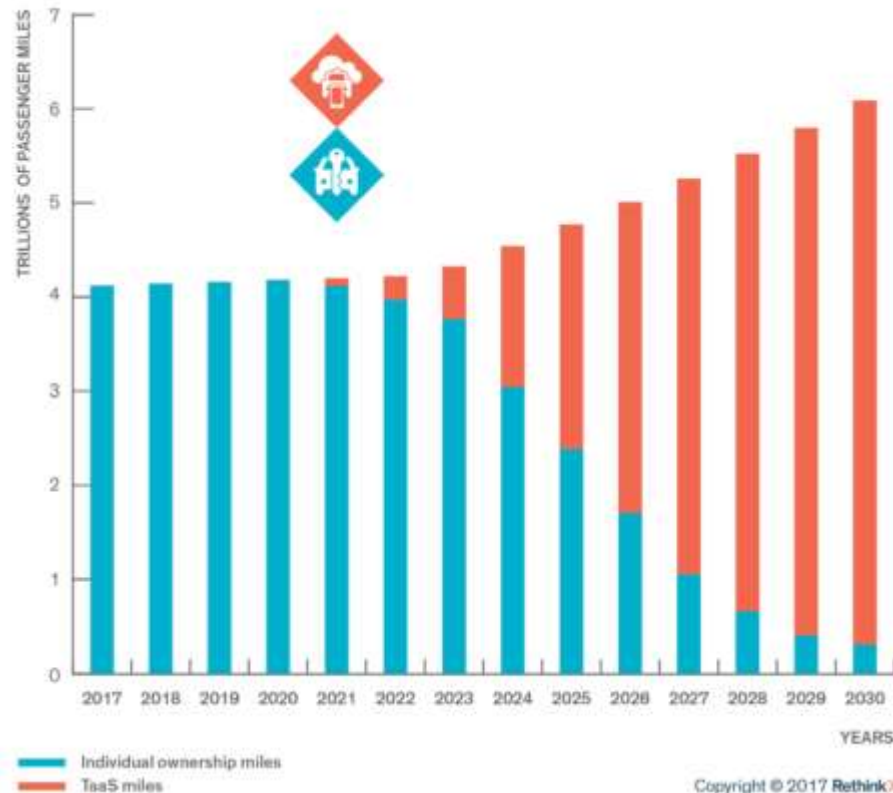
» New IO ICE vs. TaaS costs



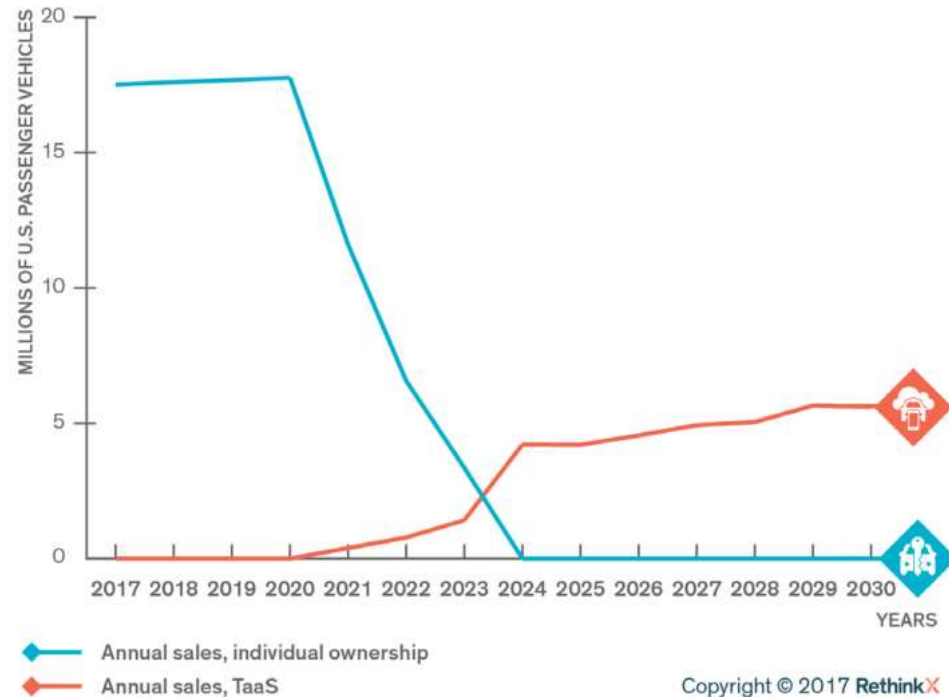
mobility-as-a-service

➤ RethinkX: Cheap TaaS rides can potentially replace miles driven by personal owners while total sales drop

» Speed of TaaS adoption



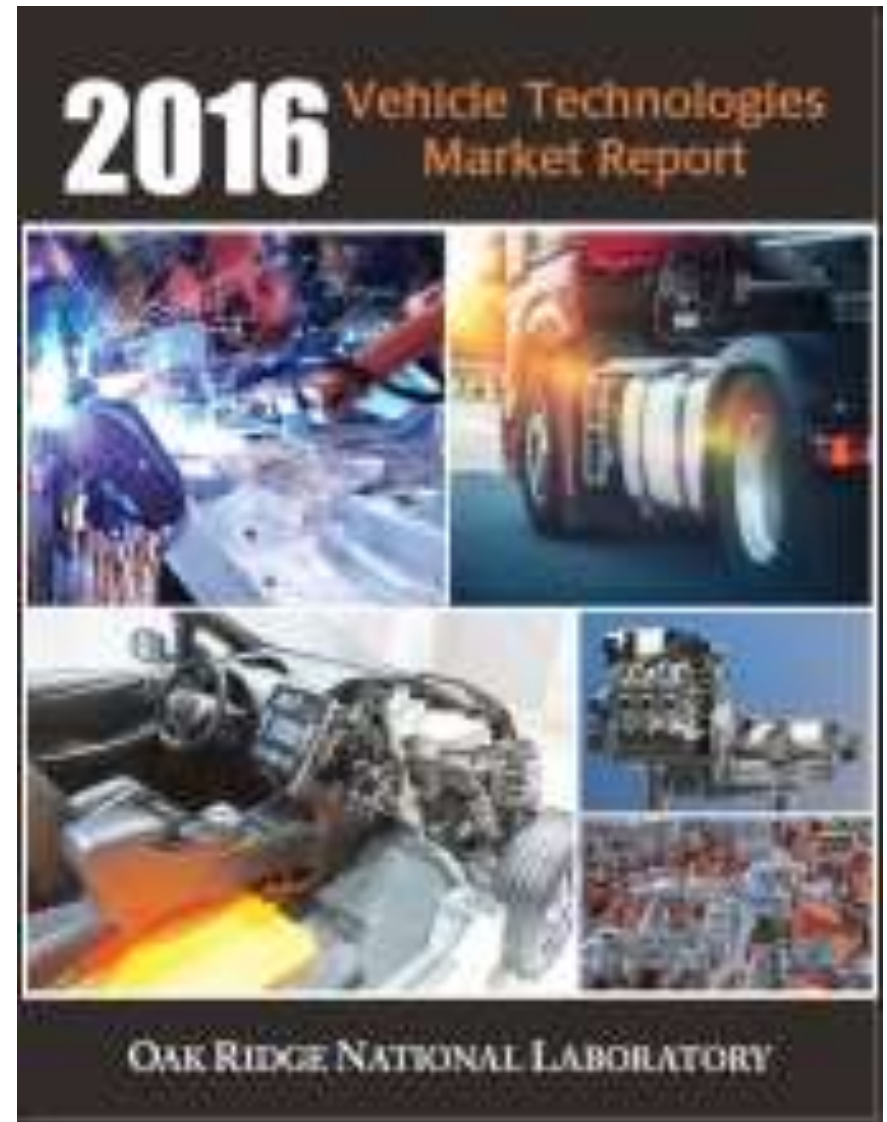
» ICE vs. TaaS: Projected trends in annual sales



publication

ORNL: Release of 2016 Vehicle Technologies Market Report

The *Vehicle Technologies Market Report* details the major trends in U.S. light-duty vehicle and medium/heavy truck markets as well as underlying trends. This report is supported by the U.S. Department of Energy's Vehicle Technologies Office, and, in accord with its mission, pays special attention to the progress of high-efficiency and alternative-fuel technologies.



summary observations



energy

U.S. gasoline prices stable, while price difference grows between regular and premium; crude exports growing

automotive

13% of LDV sales worldwide are in U.S.; China and Norway top EV markets in the world

tech/enviro

Fuel economy at all-time high; Bolt cheaper than expected; CAVs can impact energy usage; single CAV can smooth traffic; mobile sensors can be used to detect air pollutants

opinion/policy

EV refueling and costs hindering market; people expect CAVs by 2025; production and manufacturing 1/3 of auto jobs; California ZEV mandates extended

17.2
2Q 2017

qar
summary